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ESTRADE'S HIGH SPEED LOCOMOTIVE AND CAR.

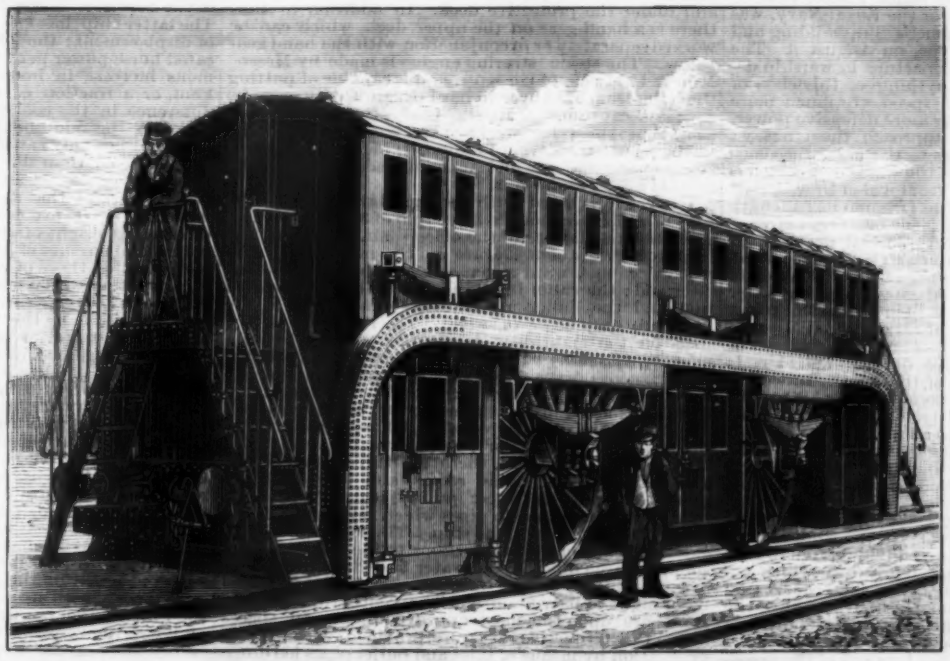
OUR collaborator Mr. Audra has already described * Mr. Estrade's conception of a type of railway rolling stock of a speed such as has never as yet been attained. Such conception is at length a reality, and there may now be seen in the shops of Messrs. J. Boulet & Co., of Paris, the locomotive and its tender entirely mounted and ready to operate. It is impossible not to be struck by the character of grandeur and power of this beautiful engine, with its six driving wheels, of one diameter in common of 8¼ feet, mounted upon three coupled axles.

The inventor's idea, it will be remembered, consists in generalizing the use of wheels of large diameter, in the extension, to high speeds, of the coupling of the axles of the motor, and in the adoption of a new and well studied style of double suspension.

The principal dimensions are as follows: Total length, 33 feet; width between longitudinals, 4 feet; diameter of the wheels, 8¼ feet; weight of engine, empty, 38 tons; weight of engine, loaded, 42 tons.

We shall not now return to a theoretic discussion of the qualities of this engine. Mr. Estrade has peremptorily answered this with faith and generosity by having built, as carefully as possible, and of true size, the one-tenth size model that he had deposited in the galleries of the Conservatoire des Arts et Metiers, and concerning which quite a number of controversies have already arisen. It is to be wished that some experiments shall soon be performed, either upon the lines of our large companies or upon those of the State. They will be deeply interesting and instructive. It does not appear doubtful that it will be possible to reach the high speeds of from 72 to 78 miles, for which this locomotive has been constructed. The equal size of the locomotive wheels, and of those of the cars, will, doubtless, in a great measure diminish the resistances of friction, and permit of gaining in speed. It must be noted that the fore axle of the locomotive, although coupled with the others, is provided with hinged grease boxes. On properly slowing up, then, it does not seem that it will be impossible to turn curves of the usual radius. This granted, we can appreciate what peculiar services will be rendered by rolling stock of this kind in the India mail service and on the great rectilinear lines of Russia, Asia, and the New World, and everywhere, in fact, where it is desirable to cross with exceeding rapidity great desert spaces between centers of population. Were it from but this standpoint, Mr. Estrade's rolling stock would merit being taken into serious consideration; and it is very desirable that the experiment shall be performed in France, since it is a question of a French idea, all the expenses attending the carrying out of which have been liberally defrayed by one of our compatriots. These experiments will give us new hints, and will permit of passing a definite opinion very opportunely at the moment when Mr. Crampton, the eminent English engineer, improving upon the beautiful and effective engine to which he has given his name, is proposing a new model with three axles, of which two are to be coupled, and which are to carry wheels 6¾ feet in diameter. In Mr. Estrade's *materiel*, the Westinghouse brake has gained a new success, since it has been selected after a study of all the devices capable of braking these high speed trains.—*Le Genie Civil.*

* See SUPPLEMENT, No. 536, p. 8556.



ESTRADE'S PASSENGER CAR.

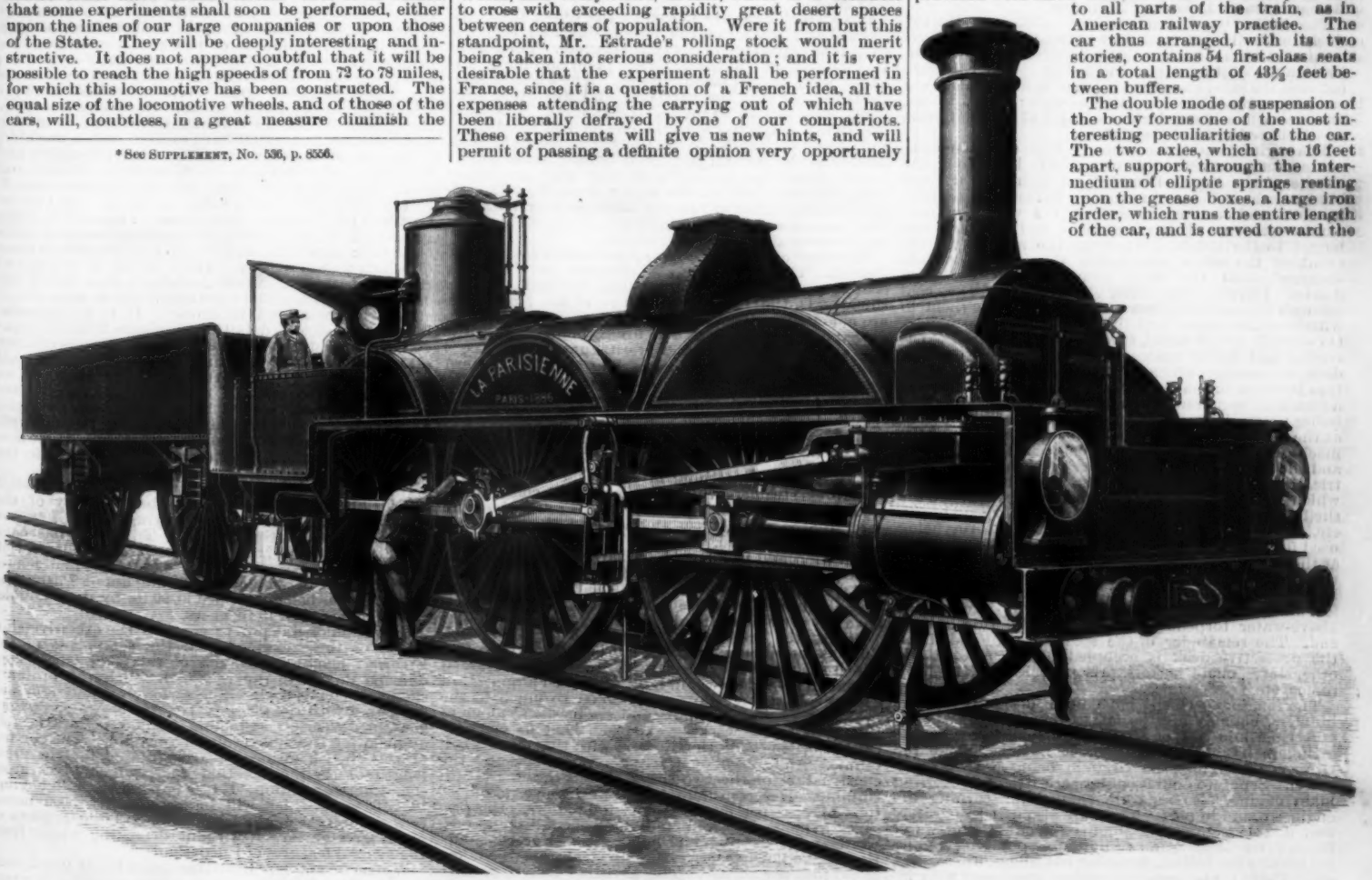
Mr. Estrade's cars are mounted in the same way.

The adoption of wheels of so large a diameter has led to the necessity of giving these cars quite a peculiar form, and one very different from that of the ordinary type.

As it was necessary to raise the flooring above the axles, an endeavor has been made to utilize the space left free between the latter by the adoption of a two-story car. The upper of these stories is on a level with the top of the wheels, which are inside of the frame. In the lower portion we thus have three distinct compartments, isolated by the wheels and prolonged toward the axles by narrow passages that may be used for water closets or for the storage of luggage, and, in the upper portion, a single saloon with central passage, to which access is had by stairways at the ends of the car. In certain respects, this general arrangement recalls that of the Vidard type, with central passageway, which is met with on a few lines in the suburbs.

All the vehicles of the same train will be connected at the level of the central passage by coupled platforms provided with hand rails, so that access may be had to all parts of the train, as in American railway practice. The car thus arranged, with its two stories, contains 54 first-class seats in a total length of 43½ feet between buffers.

The double mode of suspension of the body forms one of the most interesting peculiarities of the car. The two axles, which are 16 feet apart, support, through the intermedium of elliptic springs resting upon the grease boxes, a large iron girder, which runs the entire length of the car, and is curved toward the



ESTRADE'S HIGH SPEED LOCOMOTIVE.

ground at the extremities. Each of these girders carries three elliptic springs, which support the body of the car through suspension rods connected with a lower frame.

The increase in the size of the wheels, which are 8¼ feet in diameter, will undoubtedly have the effect of reducing the tractive stress; but, with Mr. Roy, who made a judicious observation on this subject in a discussion of the Society of Civil Engineers, we may ask whether such reduction will be very perceptible It will likely not exceed 1½ kilogramme per ton hauled, that is to say, it will reach nearly a tenth of the mean stress that the locomotive ought to develop during a normal run over an ordinary line, taking into consideration the resistance of the air, of curves, of gradients, and, in a word, of all resistances that are independent of the diameter of the wheels. However this may be, the experiment is, in every respect, of the most remarkable character, and we shall watch it with the greatest interest.—*La Nature.*

THE NEW BRITISH WAR STEAMER ORLANDO.

THE Orlando, the first of the belted cruiser class, of which seven are now building for the Royal Navy, was launched from the yard of Palmer's Shipbuilding and Iron Company, Jarrow-on-Tyne, on August 3. The new cruisers are quite a new departure in warship design, and, while superior to anything of this class of war vessel afloat in point of speed, are much more heavily armed, and have greatly more defensive power, than the Mersey class, which approach them nearest from a constructive point of view, the chief difference consisting of a belt of armor at the water line which is fitted in the Orlando class, and from which they derive the name of belted cruiser. The Orlando has a length between perpendiculars of 300 feet; breadth, extreme, 56 feet; depth, moulded, 37 feet; normal draught, 21 feet; and displacement 5,000 tons. The armor is compound, or steel faced, and consists of a belt 200 feet in length, extending from 1 foot 6 inches above the water line to 4 feet below. This belt is 10 inches in thickness, and is backed with 6 inches of teak secured in steel plating 1 inch in thickness. On a level with the top of the belt there is a protective deck, which extends throughout the whole length of the vessel. In way of the belt this deck is perfectly horizontal, and is formed of 2 inches of steel plating; beyond the belt at both ends it is inclined downward to an angle of 30°, and is 3 inches in thickness. All openings in this deck are fitted with either armor shutters or shell proof gratings, and those necessarily open in action are also fitted with coffer-dams.

By means of the armor belt amidships and the protective deck plating, all fore-and-aft, the whole of the vessel under this deck is rendered invulnerable to shot and shell, and forms an unsinkable raft, in which are placed the engines, boilers, magazines, shell rooms, and steering gear. When in action, the movements of the machinery, the steering of the ship, and the firing of the guns are under complete control from the conning tower, a massive structure at the fore end of the vessel. The look-out men in this tower are protected by 12 inch steel faced armor, and all the communications to engine rooms, magazines, steering wheels, etc., pass through a tube of steel 8 inches thick. The stem, which forms a ram, is exceptionally strong, and is well supported by the framework of the vessel and the protective deck. The ram, sternpost, and propeller brackets are each of cast steel, and manufactured by Messrs. Spencer & Sons, of Newburn.

The hull of the Orlando is built of Siemens-Martin steel, and is divided into over 100 watertight compartments. An inner bottom extends throughout the entire length of the engine and boiler spaces, the space between the inner and outer bottoms being divided into compartments, which are fitted as water ballast tanks. The vessel has three decks exclusive of the platforms which cover the magazines, etc.

The engines and boilers occupy four separate compartments arranged in a fore-and-aft line along the middle of the vessel, bounded on each side by coal bunkers about 5 feet in width. Between these coal bunkers and the vessel's side are the wing compartments, which are always kept clean, so that access can be got to the ship's side behind the armor. In the event of the ship's side below the armor getting damaged, and the wind compartments becoming flooded thereby, the outer bulkheads of the coal bunkers are made of great strength to enable them to withstand the strain that they would be subjected to. On one side of the vessel, throughout the length of the engine and boiler spaces, and below the protective deck, is a passage which forms a protected communication between the ends of the vessel, and also serves as a means of communication between the engine and boiler rooms. The magazines are situated in the hold at the middle line of the vessel, forward and aft of the machinery spaces; the spaces between the magazines and the ship's sides are used for provision rooms, electrical stores, shaft tunnels, etc. On the platforms, which form the crowns of the magazines, etc., are the shell rooms, spirit rooms, magazines for torpedo heads, etc., the remainder of the space on these platforms being used for working ammunition. On the protective deck at the sides, in way of the engines and boilers, are the upper coal bunkers, which are divided by watertight bulkheads into lengths of about 12 feet. Immediately foreward and aft of these coal spaces are situated the above-water torpedo tubes, one at each side at each end. The remainder of the space forward and aft on the protective deck is occupied by carpenters' and other stores, chain lockers, prisons, officers' stores, slop rooms, etc.

The engines, which have been designed by the builders, embody all the latest improvements in engineering, and are of the triple expansion type, the cylinders having a stroke of 42 inches. There are two sets of engines, the Orlando being a twin screw vessel. Separate double engines are fitted for reversing main engines, also separate engines for turning the engines round in port. There are also fitted separately two double centrifugal pumps for circulating water through condensers, and eight double pumping engines for feeding the boilers, pumping out bilges, fire service, etc. There is also separate surface condenser with independent air and circulating pumps for condensing all the steam used by the auxiliary engines throughout the ship. Steam is supplied by four boilers, having in all twenty-four corrugated furnaces, constructed for a working pressure of 130 lb. per square inch. They are also arranged for working under forced draught with closed stokeholes, the air being supplied by eight fans fitted with direct engines to each, which will run at about 600 revolutions per minute.

The crank shafts are hollow, and of Vickers steel; the shafting is also hollow, of Whitworth's fluid compressed steel, the cylinder liners being made of the same material by the same makers. The main bearing frames, piston and connecting rods, eccentric and slide rods, stays, etc., also the pistons, are of steel. The centrifugal pumps for main engines have been constructed by J. & H. Gwynne, and the auxiliary centrifugal pumps and fans by W. H. Allen & Co. Every care has been taken to make the engines as light as possible, consistent with efficiency and maintaining a large factor of safety, for which purpose steel has been adopted very largely. The engines will develop on trial about 9,000 indicated horse power when working under forced draught, and are expected to maintain a speed of 19 knots.

The Orlando can be steered by hand or steam, the gear for each being situated aft, below the water line, and under the protective deck. In addition to this, there is a hand gear on the upper deck, which can be worked separately or in conjunction with the hand gear below. The steam steering engine is made by Messrs. Muir & Caldwell, of Glasgow, and is capable of putting the helm from hard over to hard over in thirty seconds. A steam capstan, by Messrs. Clark, Chapman & Parsons, is provided for working the chain cables. The boats, which are eleven in number, including a 30 foot steam cutter and a 39 foot steam pinnace, are all stowed on skid beams amidships.

The vessel is fitted with two military masts, in the tops of which are mounted a couple of 3 pounder guns. The accommodations of the officers and men, numbering altogether about 420, are on the main deck. The officers' cabins, ward room, etc., are situated at the after end; the cabin bulkheads are all of corrugated iron, and the lining at the ship's side is of steel, the furniture only being of wood. The remainder of the space on the main deck is occupied by the seamen, marines, and petty officers. The pumping and flooding arrangements have been carefully planned, and are very complete. For fire purposes there are two large fire pumps fitted in the engine rooms, and a system of fire pipes led all over the vessel with hose connections at frequent intervals. For pumping water out of the bilge, ballast tanks, etc., there are three steam pumps also fitted in the engine rooms and four Downton pumps on deck. All these pumps, including the fire pumps, are connected to pipes which have branches to every compartment in the ship. The main engine circulating pumps have connections to the bilges, so that should a large quantity of water find its way into any of the machinery compartments, these pumps could also be brought to bear upon it. The ventilating arrangements are upon the most approved plan. All spaces above the protective deck are provided with natural ventilation by means of inlet and outlet pipes led down from the upper deck. The magazines, store rooms, and all other places below the protective deck are fitted with artificial ventilation, steam fans and a system of air trunks being provided for that purpose.

The armament of the new cruiser will be exceedingly powerful, and consists of two 9·2 inch 22 ton guns, ten 6 inch 5 ton guns, six 6 pounder and ten 3 pounder Hotchkiss quick-firing guns, and numerous boat and field guns.

The 9·2 inch guns are placed on the upper deck, one forward and one aft on the middle line, and each has an uninterrupted arc of fire of 240 degrees. These guns are mounted on Vavasseur center pivot automatic carriages, with central powder hoists. The working platforms revolve with the carriages, and are fitted with strong steel shields to shelter the gunners. There are three shell hoists to each gun, one on the middle line and one on each side. With this arrangement of shell hoists and the central powder hoist, the guns can be loaded in any position. The 6 inch guns are placed along the broadside on the upper deck, five on each side; the end guns are placed on projecting galleries, which enables the two forward ones to fire right ahead and the two after ones right astern.

The remaining six guns have a horizontal range of 120 degrees. These guns are also mounted on Vavasseur center pivot automatic carriages, covered by steel shields. Of the machine guns, two of the 3 pounders are mounted in the mast tops, and the remainder are placed on the main deck and fire through ports in the ship's side. The bow and stern guns, which are 6 pounders, are capable of firing right ahead and astern respectively. There are altogether eight tubes for discharging torpedoes, four being below water and four above.

EXPRESS ATLANTIC STEAMERS.

THERE is really nothing in the world like the fleet of express steamers which now maintain communication between the old and new worlds; and the more carefully the ships, their engines, and their performances are examined, the more cause do we find for admiration and wonder. Familiarity does not in this case produce contempt, but it does evoke criticism, and splendid as the achievements of the engineer and the shipbuilder have been, both are agreed that they have not yet reached finality.

One of the first things to suggest itself about such ships as the Etruria or the Umbria is the vast cost at which their efficiency has been obtained—a cost which no one in his senses would have suggested a quarter of a century ago. We do not here refer so much to the outlay of capital on ships and engines, enormous as that is, as to the working expenses. Let us compare the performance of the Etruria with that of the Britannic. An interval of nearly ten years separates the construction of the two ships. The Britannic is still running. Her consumption is, we believe, about 90 tons of coal per day of twenty-four hours. Her passages average, Mr. John tells us, 8 days 9 hours outward, and 8 days 2 hours homeward. Her consumption may, allowing for getting up steam, etc., be taken at 840 tons per voyage. The Etruria's fastest passage has been 6 days 5 hours 31 min. Her average we do not know, but we shall not be far wrong if we call it 6 days 12 hours. She burns 320 tons of coal per day of 24 hours, or, making allowance for getting up steam, etc., 2,350 tons of coal on the trip. She makes the passage in a day and a half less than the Britannic. To save this day and a half, the consumption of coal is augmented by no less than 1,400 tons. That is to say, the consumption has been nearly doubled to save thirty-six hours in time. This is startling enough, but if we compare the fastest ship named by Mr. John with very fast ships, the figures are, in one sense, yet more remarkable. Let us take, for example, the Servia, and compare her with the Etruria. The best passage of the latter is, in round numbers, 6¼ days; the best passage of the former is, also in round numbers, 7 days. Using Mr. John's figures, and neglecting coal spent in getting up steam, etc., we have, for the Etruria, $315 \times 6{\cdot}25 = 1{,}968{\cdot}75$ tons, and for the Servia, $205 \times 7 = 1{,}435$. That is to say, over 500 tons of coal are expended in shortening the passage by 18 hours. It may be urged that this is not all, and that the difference in the dimensions of the two vessels must be taken into account. But it so happens that the Servia is a larger ship than the Etruria, the displacement of the former vessel being 10,960 tons, and of the latter 9,860 tons, or 1,100 tons less. The indicated horse-power of the Servia is 10,300, and that of the Etruria 14,321. The latter ship has 1·45 indicated horse-power per ton of displacement; the former a little less than 0·94 indicated horse-power per ton of displacement. The enormous increase in horse-power required to put on a knot, or a fraction of a knot, in speed explains the difference in the coal consumption of the two ships. Nor does the additional expense end here. It will be seen that not only can the Servia make a trip with 500 tons less coal than the Etruria, but she has available, for some purpose or another, 1,100 tons more displacement. Part of that can be devoted to cargo, part to passenger space, even after due allowance is made for the greater weight of the hull. But furthermore, the boilers and engines of the Etruria weigh a great deal more than do those of the Servia. The more carefully we investigate the construction and performances of the two ships, the clearer does it become that the price paid for reducing the time of transit between Liverpool and New York seems to be out of all proportion to the result gained. If such a ship as the Etruria can be made to pay her way, then the profit earned by such a vessel as the Servia must be very large, while that earned by the Britannic ought to be colossal. We believe that the truth lies between the two statements, and that the fastest ships in the Atlantic trade are partly supported out of the earnings of their slower sisters. Mr. John has hinted that the express Atlantic steamer of the future will carry no cargo, and this, we think, is more than probable. If any ship is built to beat the Etruria, it is clear that there will be no space left for cargo—engines, boilers, and coal demanding every ton of displacement available.

The members of the Institution of Naval Architects were favored with an opportunity of seeing the Etruria, the Cunard Company sending a tender to take them on board the vessel as she lay in mid-stream, the day before starting for New York. It would be waste of space to attempt in a few words to give an adequate idea of what the Etruria is like; it will be enough to say that she is 500 ft. long, 57 ft. beam, and draws 22 ft. 6 in. Her engines have one high-pressure cylinder 71 in., and two low-pressure 105 in. diameter, with a stroke of 6 ft. She has 72 furnaces, and the working pressure is 110 lb. Her engines make about 65 revolutions, or a piston speed of 780 ft. per minute. It is impossible to look at these engines without remarking the enormous gap which separates them from the typical steam engine of books, and, indeed, of very many makers. The use of piston valves of huge dimensions seems to multiply the number of cylinders; and the great number of adjuncts serves to complicate the whole machine, until even a trained engineer stands bewildered before them. One thing is certain. No amount of college training, no amount of mathematical education, could have evolved such a machine. This kind of training can only teach principles, and the success of such engines as those of the Etruria and ships like her depends from beginning to end on detail, and a consummate knowledge of detail can only be acquired by prolonged experience. It would be quite impossible, we feel certain, to make our meaning quite clear to any one who has not seen such engines as those of which we are writing. There is not a member of the Institution of Naval Architects who visited the engine-room of the Etruria who will not at once understand what we intend to convey. It is this consummate knowledge of detail which places British marine engineers in advance of the marine engineers of every other nation under the sun. But when we have said so much in admiration of the Etruria's machinery, we may proceed to criticise it, and to ask, Could not equally admirable results be obtained by far simpler machinery? The abundance of detail, the multiplicity of parts, is in the Etruria overwhelming. It does not follow that they are necessary or desirable in the propulsion of a ship.

Having visited the Etruria in the morning, we visited the steamship British Prince, the property of the British Shipowners' Company, lying in the Langton Branch Dock, in the evening. This ship has compound engines by Messrs. Harland & Woolf, of Belfast. She is a vessel of some 4,000 tons, and makes over 12 knots, her engines indicating about 2,700 horse-power, steam being supplied at 90 lb. by three double-ended boilers with 18 furnaces.

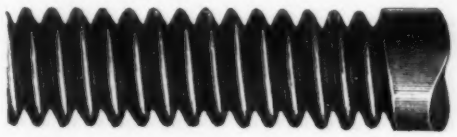
It was impossible not to contrast the excessive simplicity of these engines with the complexity of the Etruria's machinery, much of this simplicity being due, no doubt, to the ease with which the ordinary slide valve lends itself to the wishes of the designer, as compared with the piston-valve system, which doubles gear in a very objectionable fashion, besides largely augmenting the dimensions of an engine. The engines of the British Prince are remarkable for the great length of their connecting rods, which gives great smoothness of motion. If it is possible to build engines in this way, which will indicate nearly 3,000 horse-power, surely it might be possible to build engines of much greater power, without departing widely from the general features of the design.

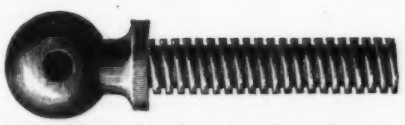
We have not left ourselves space to say much concerning Mr. Parker's paper, which contains a great deal that is highly suggestive. There is, however, no

passage in it which deserves so much consideration as that in which he says: "In regard to the economical application of the work after it has been produced, to the propulsion of vessels, there is also room for great improvement, for, according to the late Mr. Froude, the greatest authority on this subject, only about one-half of the total power exerted by the engines is effective in propelling the vessel, the remainder being expended in overcoming frictional and *other resistances*." The italics are ours. We have emphasized them because they indicate a weak place in engineering science. What are these "other resistances"? Is it too much to say that no one possesses any adequate information concerning their nature? The loss they represent is enormous. The gentlemen who believe in theory before all things have here a splendid chance open to them. If they will come forward and say how no less than 6,000 indicated horse-power is wasted in the Etruria, they will do a good work. On what is this 6,000 horse-power expended? Let us assume that not less than 1,000 horse-power is absorbed by engine friction, where does the remaining 5,000 horse-power go? The quantity is no trifle. It ought to be possible to ascertain, with some approach to accuracy, on what it is expended. Not less remarkable than the loss is the fact that no one has ever even attempted to define with precision on what it goes. There are, of course, numbers of vague explanations floating about, but they all elude the grasp when we attempt to handle them. One, for example, is that the friction of screw blades in passing through the water is quite sufficient to account for most of the loss. But the loss is as great in the case of the paddle-wheel as with the screw, and it is quite certain that the waste by friction in this case must be as nothing when compared with that of the screw.—*The Engineer.*

SCREW FORGING MACHINES.

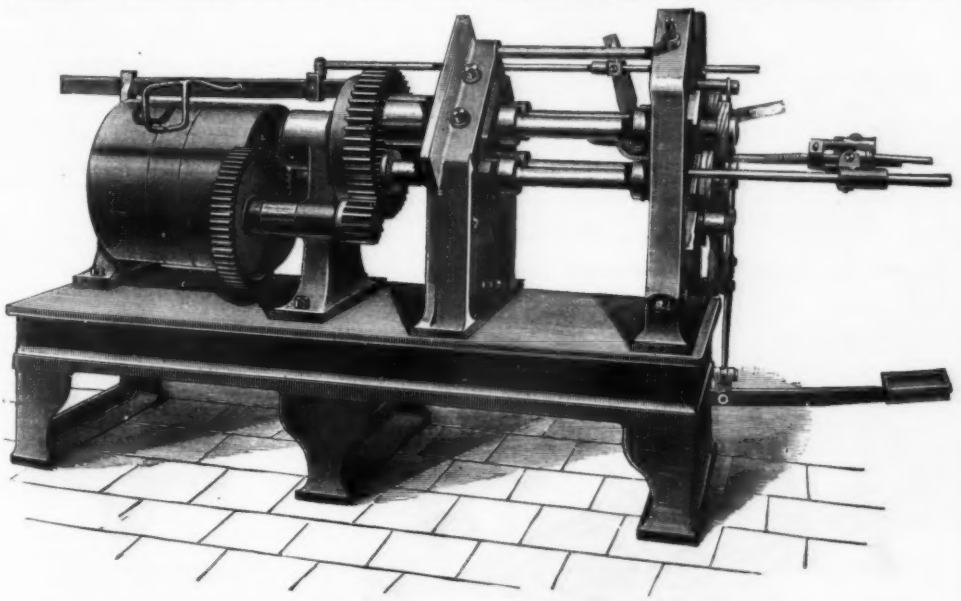
THE machines which we show are by Fairbairn & Wells, of Hardman Street, Manchester, and contain the most recent improvements. They have been arranged

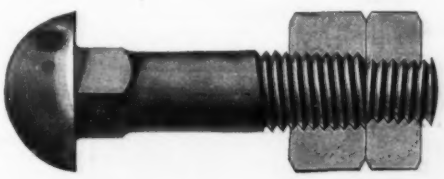


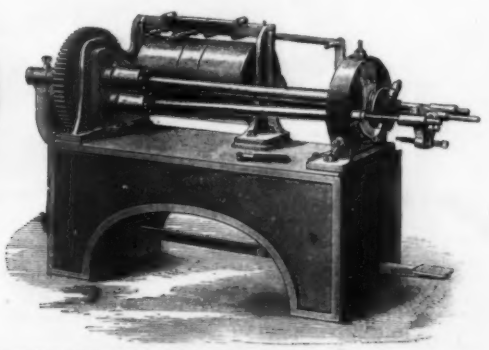


for a much wider application than formerly, for until recently these machines were confined to the manufacture of screws alone; but, with modifications, they have now been applied to the manufacture of spherical balls for cycles, right and left screws for railway coupling screws, stretching screws of various kinds, steel projectiles, twist drills, spindles of various kinds, axles, shafting, etc.

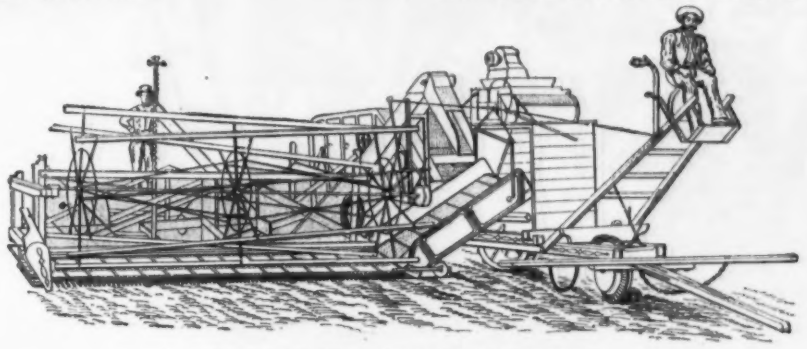
Previous to these applications, the shaft and impressing rollers of the machine had to be twisted to produce the longitudinal motion of a screw, and it will be evident that, with such long rollers as have to be used for large screws and various other articles, these twisted rollers, while they might be true to the pitch and shape of thread in the middle of the roller, were certain to be materially out of pitch at each end. In consequence of this defect, the older machines were confined to short rollers, and these also being necessarily of small diameter, small sizes of screws, such as below ½ in., could not be made on them, which restricted variety of production and range of the machine. In the new machines, the longitudinal motion of a screw is obtained solely by a difference in the diameter of the rollers, and the impressing grooves are cut to the true pitch. When three rollers are used, two of them are placed absolutely parallel, and the larger one is slightly inclined, to give similarity of angle to the three. When four rollers are employed, then two are parallel and two are inclined, there being two large and two small. By this method, any length of rollers can be used, and for some purposes two rollers are used on each shaft, as in the case of making some kinds of projectiles.







IMPROVED SCREW FORGING MACHINES.



HOUSER'S CALIFORNIA HARVESTER.

For a long time it was generally accepted as a fact that from cutting screws in the ordinary way there was no escape, no alternative method of construction, and consequently comparatively little progress has been made in this most important branch of mechanical construction. There can be no doubt that the records of the Patent Office furnish abundant evidence of attempts to improve cutting machines for making screws, but further than this there has not been much activity displayed in originating new methods.

As screws are at present made by cutting a continuous groove round a bar of iron, it cannot be doubted that it is an operation which is capable of improvement, whether the material is either of iron or steel. When the former is used, especially if it be fibrous, the fibers being cut across at such short intervals renders the thread which is left between the grooves very liable to be stripped off, and it is well known that steel subjected to the same treatment will readily snap from a sudden blow. Very rarely, indeed, will either iron or steel withstand a bending strain or blow, especially after a screw has been cut upon it.

To get over these defects is the object of the present invention. The method of operation is briefly as follows: A series of rollers, which may be two, three, or four, but not more in number, have grooves cut on their peripheries corresponding in shape and pitch to the threads which may be desired for a bolt.

The screw blank, while hot, is placed between these revolving rollers, and the heated blank is caused to revolve by their pressure, and at the same time receive the reverse impression on the bolt, which is a screw thread. The thread is, as it were, dovetailed into the body, and then welded on the bolt. That this is so, can be seen by laying the section of the threads bare, and treating them with acid; the fibers of the iron are then shown bent to the shape of the thread, which thus becomes a portion of the bolt itself, which may be worn away by work and time, but cannot be stripped or knocked off, as with a cut thread. Either iron or steel bolts, when threaded in the machine, will bend to a greater angle than the plain iron would allow before being operated upon. Screws that have to stand very hard usage, such as vise screws, screw jacks, coupling screws, are much stronger and more durable made in this way, and may be made smaller in diameter, for very often screws of a larger diameter have to be used, in order to get a larger bearing surface of thread, for fear of being stripped off.

Another feature of superiority shown by these machines is in the durability of the rollers. Cutting dies require to be repaired or replaced very often, and when new, by cutting keenly, the screw is well formed, but as it proceeds the edge is worn off, and irregularity in size of screws is the result, besides the time lost in changing. But the impressing rollers, when once set, which can be done in a few seconds, may go on for years, and never require to be touched.

We show several examples of the work done by the machines, the most recent feature being a fish plate bolt with right and left handed screw and lock nut. We understand that these bolts can be made at a cost only slightly greater than the bolts ordinarily used.—*Industries.*

HARVESTING MACHINERY.

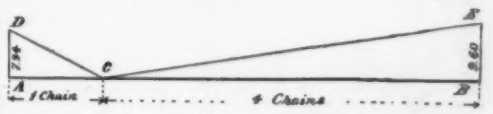
"GRAIN Handling in California" formed a paper by J. H. Cooper, read before the recent meeting of the American Society of Mechanical Engineers. This State furnished one fifth of the grain exports of the United States, and one-eighth of the wheat crop. The fields were large, one being 9,200 acres in extent, and to handle the crops the most approved machinery is required. Mr. Daniel Houser, a farmer, is the inventor of a machine (see illustration) by which four men and sixteen mules averaged 20 to 35 acres per day for fifty days; 1,000 acres were cut in thirty days, and the grain put in the sacks for 85 cents per acre. The cut is from 12 ft. to 20 ft. wide.

In other machines the wheat is cut, thrashed, put into bags, and the bags sewed up; the latter are then dropped on the ground and afterward gathered. These machines are sometimes moved by as many as thirty head of cattle, and do their work automatically. The paper closed with an account of the elevators and shipping facilities of the Nevada Warehouse and Dock Company. One warehouse is 770 ft. long, and one 912 ft. An elevated road runs through them for transferring the sacks; there are 2,300 ft. of dock frontage. The capacity of handling is about 1,200 sacks per hour.

AN EASY METHOD OF ADJUSTING A FIELD LEVEL.

IN the absence of a level surface of water, the following is a quick and easy method of adjusting a field level:

Drive two pegs, A and B, firmly in the ground about 5 chains apart, and set up the instrument midway be-



tween them. Then adjust the spirit level in the usual way at right angles to the axis on which the telescope turns. When this is done, without shifting the instrument, take the readings of the two pegs, A and B, which will give their true difference of level, say 2·46 feet. Now shift the instrument to a point, C, say 1 chain from A and 4 chains from B, and take their readings as before. If their difference in height corresponds to that given by the central reading, the level is in adjustment; if not, it must be adjusted accordingly. Referring to the figure herewith (which is greatly exaggerated for the sake of illustration), we may assume the readings at A and B respectively to be 7·94 and 9·60, which give an apparent difference of 1·66 ft., but the true difference is 2·46 ft., therefore the error of the reading at B = 0·80.

Hence by similar triangles, A C D and B C E, we have

$$A\,D : B\,E = A\,C : C\,B$$

$$\text{or } A\,D = \frac{AC}{CB} \times B\,E = \tfrac{1}{4} B\,E$$

$$= \tfrac{1}{4} \times 0{\cdot}80 = 0{\cdot}20$$

The correct reading of A then becomes 7·94 + 0·20 = 8·14. Alter the line of collimation until the instrument gives this reading, when it will be found in adjustment.

Jamaica, W. I. C. L. M.

AN ENDLESS RAILWAY.

We give in the cuts accompanying this article a representation of a vehicle, designed in great measure as an experiment, that lays its own rails. It is designed by M. G. Frascara. After the perspective view of it,

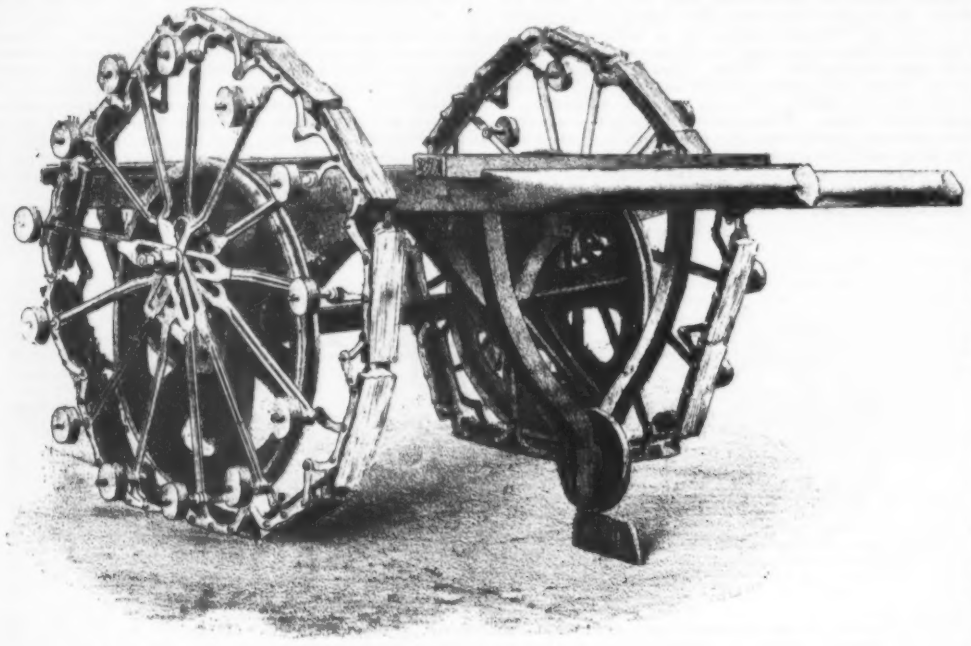


PLATE I.

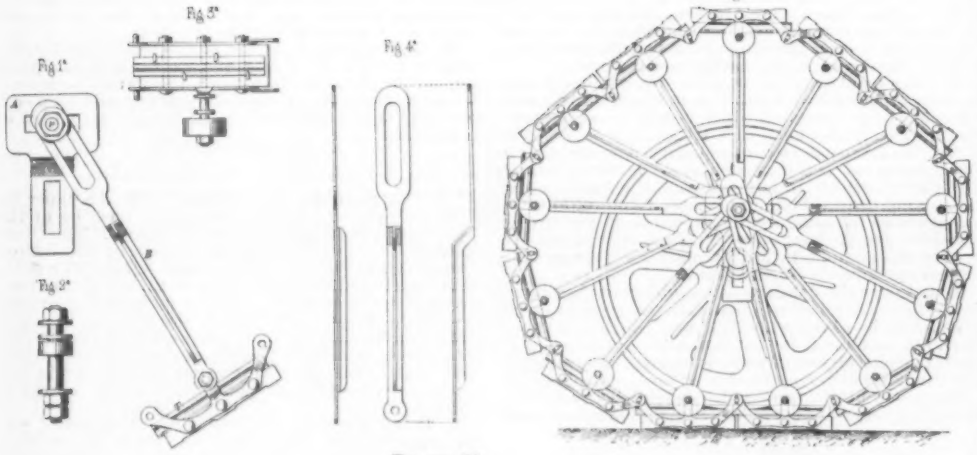


PLATE II

THE ENDLESS RAILWAY.

Plate I., the details of its construction are given in Plate II., Figs. 1 to 5, and Plate III., Figs. 1 and 2.

Fig 5 of Plate II. represents the jointed polygon, composed of 13 wooden bars with rectangular bases (see Plate III.), each attached by a hinge joint to its two neighbors. A short piece of rail is carried by each bar. By radii or shifting spokes the whole are connected to a common central pinion. Fig. 1, Plate II., shows a segment, T, with radial bar, B, and central pinion, P; and the piece, A, carrying the pinion, the latter being shown in Fig. 2. The piece, A, has two rectangular slots, by which the position of the axis can be changed,

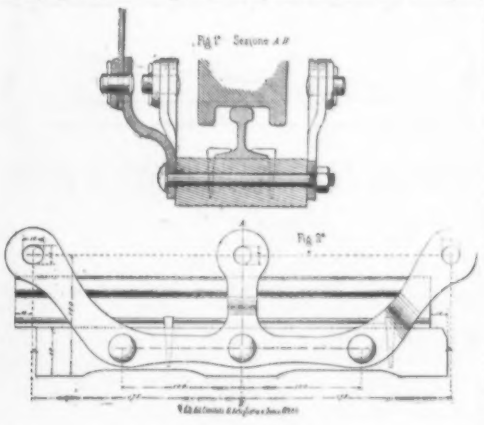


PLATE III.

and the same shifted upward or downward and forward or backward. This arrangement was for experimental observations on the effect of such change of position.

The wheel of the vehicle has a U-shaped tire, which turns inside of the articulated polygon. As the wheel, under the effects of traction, advances, the polygon also rotates, and its members assume almost symmetrical positions under the influence of gravity. One member drops upon the ground as another leaves it, so that a portion of rail is always in advance of the wheel.

The radial bars, Plate II., Fig. 4, have each its own offset, so that they maintain always a vertical position.

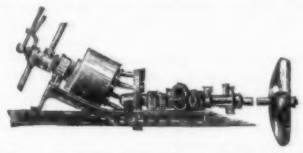
As the weight of the car come successively upon each segment, it forces it downward, but so slightly that even in soft ground the depression is inconsiderable. Of course, each piece receives no weight until well in position, and does not leave the ground until the wheel leaves it. Adherence is one of the forces that opposes the lifting of the segments, but this is of little account.

A circular counterweight is shown for each segment. These balance their weight and prevent flexure of the central bearings.

A number of experiments with heavy loads, ranging from three to five tons, were carried out, and the force of traction was measured by a dynamometer, and compared with the force required to propel an ordinary cart. The latter had wheels 1·20 m. diameter, with tires 50 mm. broad. The wheel within the polygon was 0·965 in. in diameter, and ran upon a rail weighing 4 kg. to the meter. Comparative tests were made on a smooth pavement, over which gravel was gradually spread. At first the ordinary cart had the advantage, but with five cm. of gravel both were equal. Irregularities of ground were found to favor the polygon. With heavy loads, running as high as five tons, the polygon had an advantage of 25 per cent. The invariability of the force required was also noticeable.—*Revista di Artglieria e Genio.*

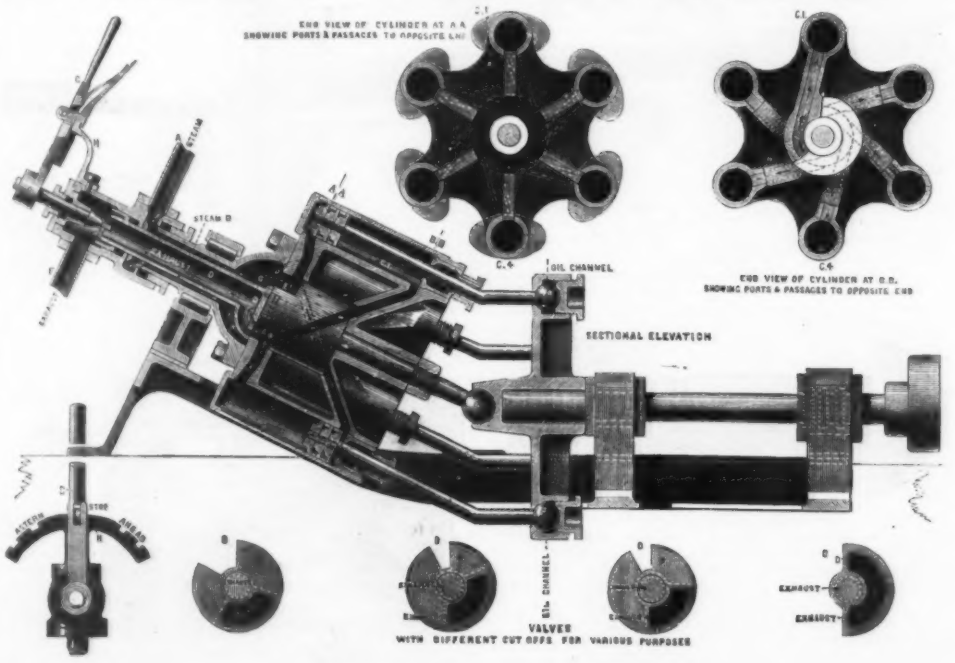
NOVEL ROTARY ENGINE AT THE LIVERPOOL INTERNATIONAL EXHIBITION.

MESSRS. SIMPSON & DENISONS, of Dartmouth, who have made the construction of small steam engines for yachts their specialty, have two exhibits, one in the main avenue and the other in the Machinery in Motion Court. One article in the latter exhibits is certainly the curiosity of the Exhibition. It is called Kingdon's patent rotary engine, though it is not a



KINGDON'S ROTARY ENGINE.

rotary engine in the ordinary sense of the word, as the motive power is obtained by means of a reciprocating movement; still, as every part of the engine, with the exception of the bed plate and bearings, rotates, perhaps the name is not misapplied. The engine consists of a cylinder placed at an angle of forty-five degrees, and supported at one end by a trunnion through which the steam is admitted and exhausted, and at the other by a pivot resting on the center of a disk. Inside the cylinder are six smaller cylinders, provided with pistons, the piston-rods of which are bent horizontally after passing through the stuffing-boxes on the cover of the large cylinder, and then attached to the disk already mentioned; the pistons are set to be at different positions, and, steam being admitted, the ordinary reciprocating motion of the pistons commences, the cylinder and the disk revolve together, and the machinery set in motion. There is only one valve, and the engine can be stopped and reversed by means of it alone. Steam is admitted at A through the passage B into the chest C. It then passes through the opening O in the valve D into the port E^1, communicating with top end of the cylinder C^1 and the bottom end of cylinder C^4, as shown by the arrows. The exhaust at the same time passes from the bottom end of the cylinder C^1 and the top end of cylinder C^2 through port E^4, then through the center of valve D to the exhaust at F. There is only one valve in the engine, which is marked D, and it does not rotate, but is controlled by the lever G, which is held in position by means of the quadrant H. By moving this lever, the engine rotates in either direction, stops and reverses with remarkable ease and rapidity. The action of this machine is extremely curious, for although the motion of the pistons in the cylinders is an ordinary reciprocating one, the entire momentum of the engine is rotary. The cylinders are not likely to become grooved in working, as the pistons have a spiral movement in one direction when traveling forward, and on the return stroke a similar motion in the other direction, the effect being that the cylinders become evenly polished by the opposite motions. Any required degree of expansion can be arranged for by the form and position of the valve, and drawings are given showing the different forms of valves. The cut-off can be varied to any extent while the engine is running. The engine is undoubtedly very compact and light, and works at a very high rate of speed, with very little noise; but experience alone can prove whether this engine is an economical one or not, both as regards the consumption of steam and durability of working parts.


END VIEW OF CYLINDER AT A A
SHOWING PORTS & PASSAGES TO OPPOSITE END
END VIEW OF CYLINDER AT B B.
SHOWING PORTS & PASSAGES TO OPPOSITE END
SECTIONAL ELEVATION
VALVES
WITH DIFFERENT CUT OFFS FOR VARIOUS PURPOSES

KINGDON'S ROTARY ENGINE.

In the main avenue these makers show a yacht's steam gig 25 ft. long by 5 ft. 6 in. beam, carvel built, of mahogany, fitted with Kingdon's patent compound surface-condensing engine, double ½ A size, with two 1½ in. high-pressure and two 3½ in. low pressure cylinders, and Kingdon's patent natural draught boiler, and fitted with outside condenser, suitable for carrying on a yacht of 150 tons and upward. The weight of this boat is 8 cwt., and the machinery, including the boiler, is only the same weight as the hull, making a total of 16 cwt. A yacht's dingey, 16 ft. long and 4 ft. beam, is shown, fitted with a smaller engine and boiler of the same description. A larger engine with a 4 in. high pressure and 10 in. low pressure cylinder is exhibited without a hull. These engines are all surface-condensing, the condenser being formed of solid drawn copper tubes of D section placed outside the boat, which are connected at the forward end with the exhaust pipe and at the after end with the air pump. It is stated that a vacuum of 25 in. is easily obtained with these condensers. The boilers are somewhat unusual in design; they are vertical, and the diameter of the steam space is considerably greater than that of the water space, which is said to entirely prevent priming; and although it gives them a top heavy appearance, the center of gravity is really very low. The engines are beautifully finished, and from this cause, and their diminutive dimensions, they attract a good deal of attention. The boats are fitted with propellers on shafts having universal joints, and by means of a lever placed over the tiller and a rod working through the rudder, formed of two brass plates, the screw can be lowered below the keel or raised above it in shallow water.—*The Engineer.*

THE occurrence of tin in New South Wales was first made known in 1852, but it was not commercially worked until 1872, although the tin is of the best quality, and ranks beside the Strait Settlements tin.

THE NEW CROTON AQUEDUCT.

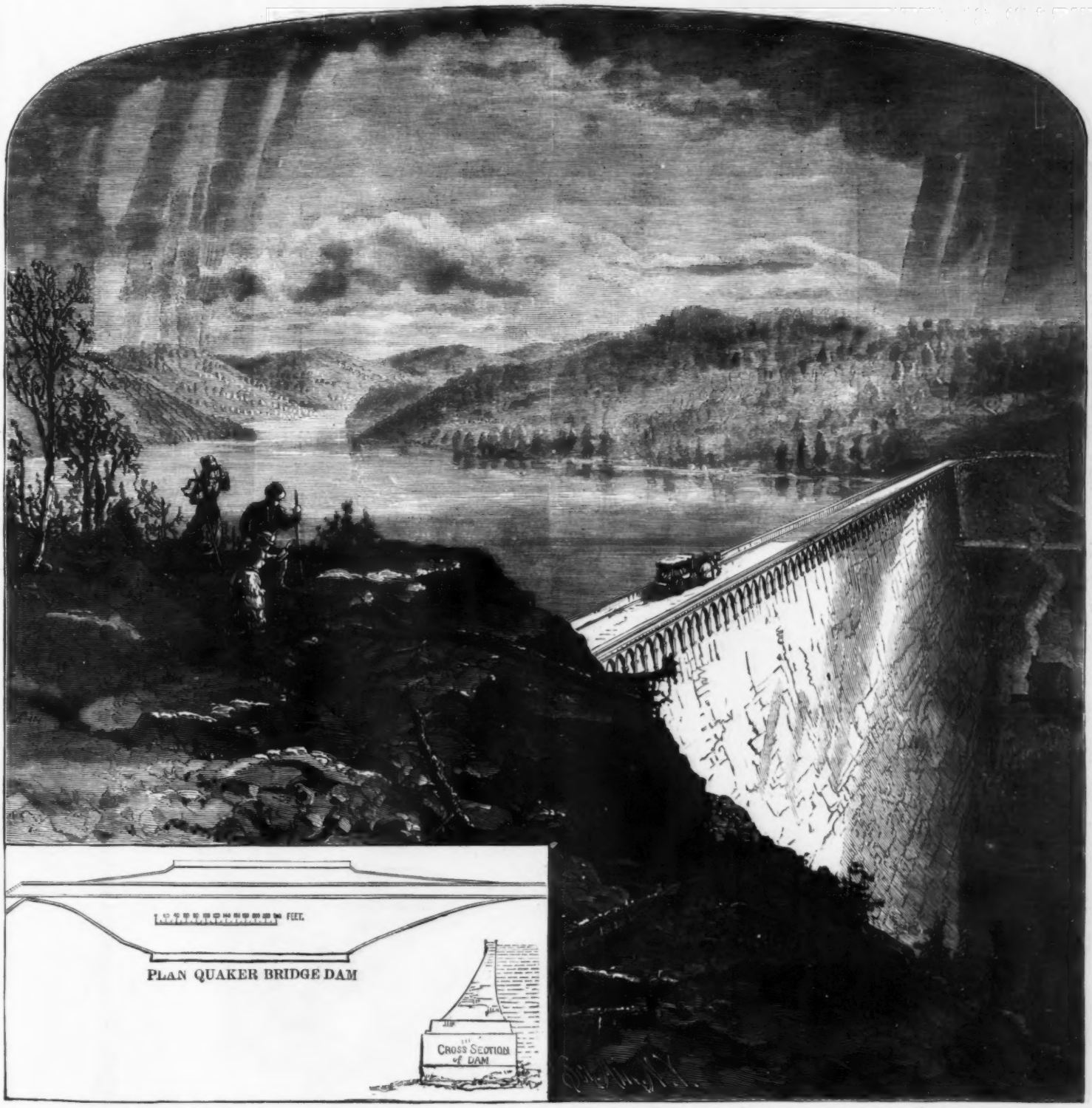
IN our SUPPLEMENT for January 10, 1885, number 471, we gave illustrations of this great work, from the official drawings prepared prior to letting out the contracts for the work. We now present engravings illustrating the work as it is actually being carried out, with map, etc.

For many years the present Croton Aqueduct—the line of which from Croton Dam to the Central Park reservoir is indicated by the heavy dotted line in the accompanying map—has been forced to carry a quantity of water much greater than its builders designed it for, and as a natural consequence it has been so weakened that nothing but the skill and incessant watchfulness exercised by those in charge have prevented it from long ago yielding to the burden thrust upon it. The necessity for quickly providing greater carrying capacity is, therefore, apparent.

It is estimated that, even in years of the greatest drought, the Croton watershed, from whence almost all of the present supply is obtained, can be relied upon to furnish 250,000,000 gallons daily, or 100 gallons per head per day for 2,500,000 people. The building of Quaker Bridge Dam would increase the available area of watershed to 361·82 square miles, and the reservoir thus formed would have a capacity of 32,200,000,000 gallons—water sufficient to cover 9,400 acres 10 feet deep. The dam will be built of solid masonry, will be 178 feet high above the bed of the river, and since the foundation will have to extend to bed rock—100 feet—the total height for a distance of about 400 feet in the lowest part of the valley will be about 300 feet; the width of the dam at the base will be about 200 feet, and the extreme length 1,300 feet. The estimated cost of this great dam is five millions of dollars. Our engraving is made from official drawings, and shows the probable external appearance of the work and surroundings

The new aqueduct now being built has a maximum flowing capacity of 320,000,000 gallons per day from Croton Dam to a point near the New York city boundary line, where it is designed to construct a large distributing reservoir to supply the annexed district; a part of the supply being there diverted, the remaining portion of the aqueduct has a flowing capacity of 250,000,000 gallons per day. The northern portion, shown in section in Fig. 4, is 13·6 feet high and 13·6 feet wide; the semicircular arch has a radius of 6·8 feet, the concave sides are on a radius of 20·92 feet, and the invert has a radius of 18·5 feet. Where necessary, the rock walls are evened with concrete, and a masonry lining built 12 inches thick at the sides and arch and 6 inches thick at the invert; but where the character of the rock justifies it, no masonry is needed. The other part of the aqueduct, about 6½ miles in length, will be circular in section, as shown in Fig. 3, 12 feet in diameter, and lined with masonry 12 inches thick. Owing to the insufficient elevation of the land, this section will be depressed about 100 feet below the other, as indicated on the profile. The Harlem River is to be crossed by an inverted siphon, the depth below the river being about 200 feet. All the masonry will be of hand made, hard burned brick, laid in cement mortar, one part cement to two parts clean sharp sand.

From Croton Dam to Harlem River the aqueduct is 28¼ miles long, and to Central Park reservoir 33¼ miles; the total length of open cuts—varying from 0 to 40 or 50 feet between the arch and ground surface—north of the Harlem is but about 3,000 feet; all the rest of the line is through solid rock. The method of building the aqueduct is by sinking shafts about one mile and a quarter apart, and working both ways from each. There are 24 shafts north of the Harlem and 8 south of it, varying in depth from 28 to 350 feet. Fig. 1 of the engravings is a longitudinal section through shaft No. 10, showing the heading, the timbering in the shaft, and the location of the hoisting machin-

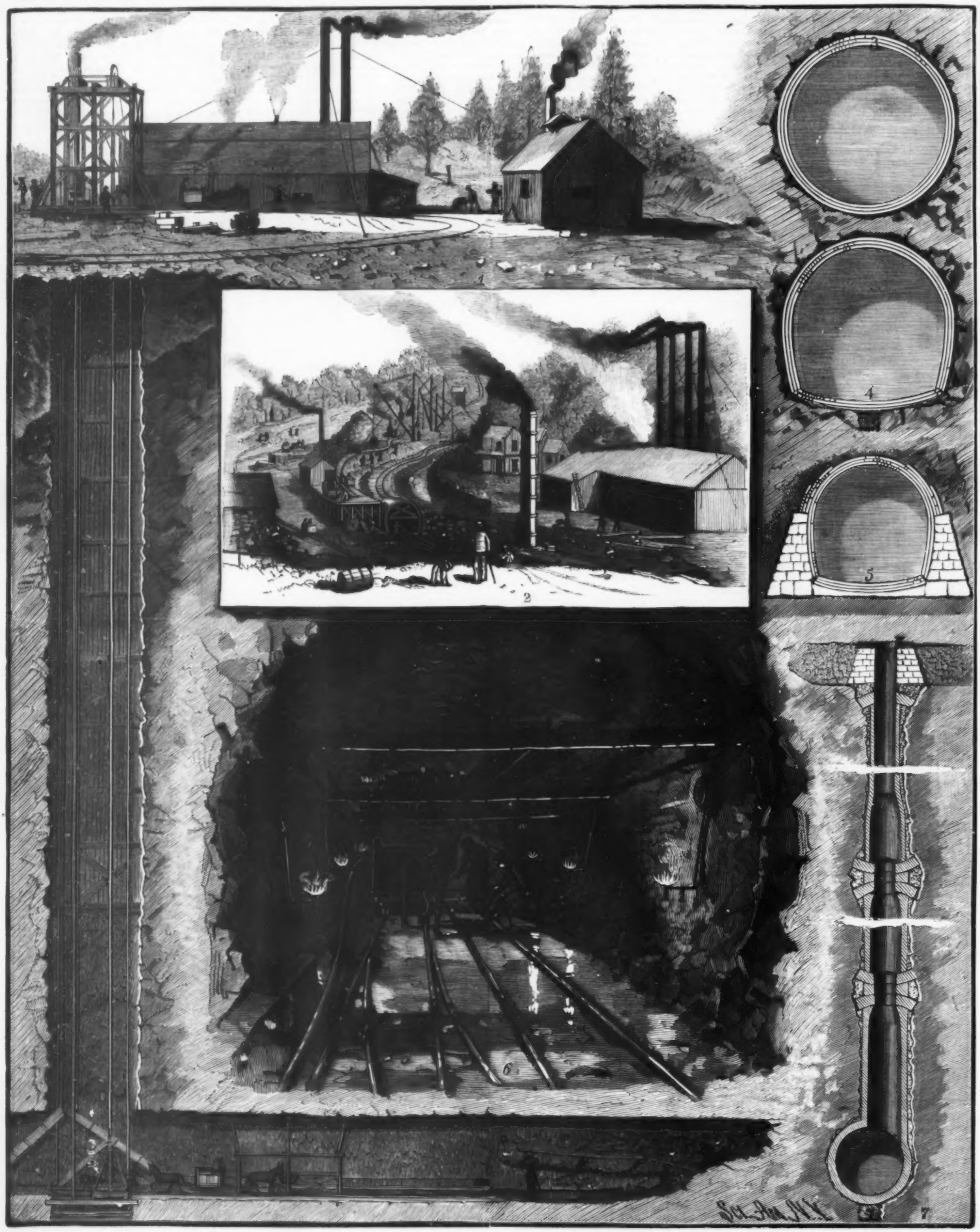


VIEW SHOWING THE CONTEMPLATED QUAKER DAM ACROSS CROTON RIVER—NEW YORK WATER SUPPLY.

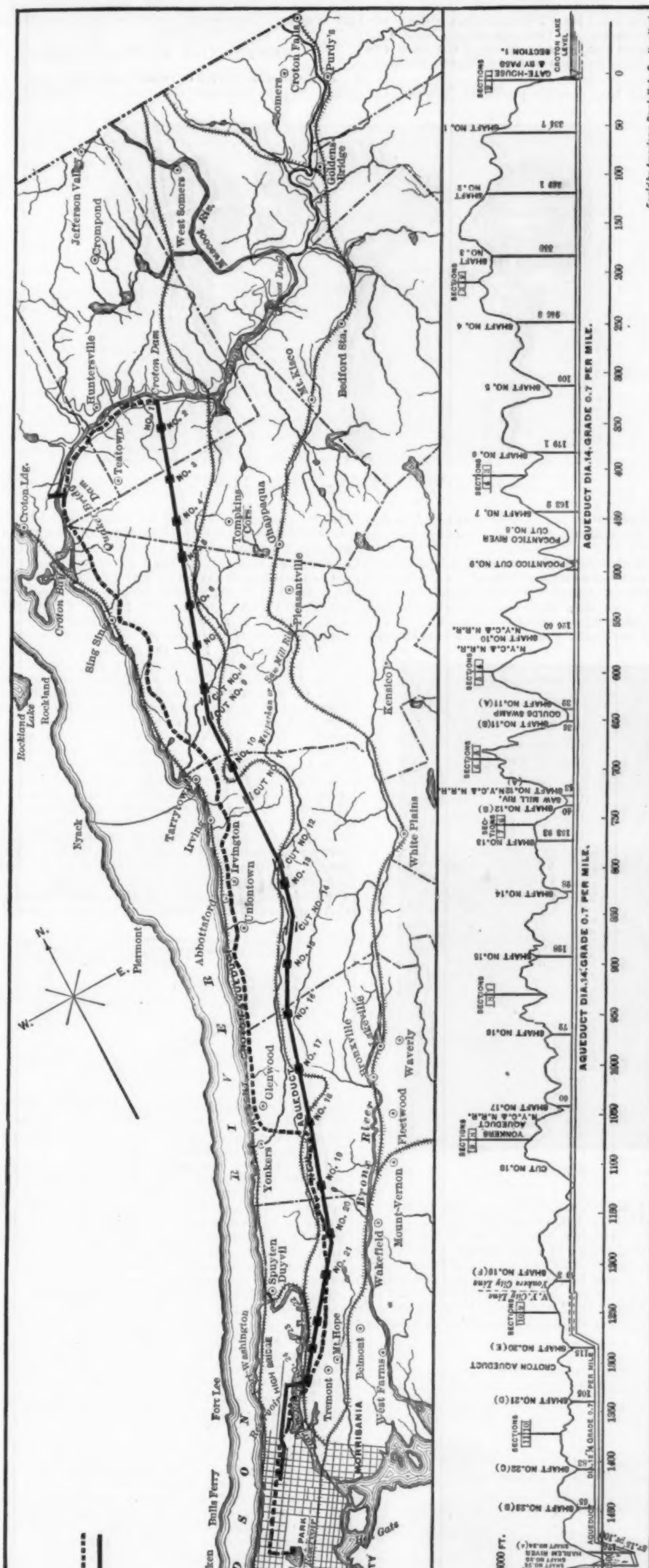
ery. Fig. 6 is an enlarged view of the same heading. The shaft is 17½ feet by 8 feet in the clear, with the longer dimension parallel with the axis of the tunnel. In the shaft run two cages, operated by a double drum Dickson hoisting engine, on one of which the loaded car is brought to the surface, while on the other an empty car is lowered into the tunnel. Steam for hoisting, pumping, and compressing air is furnished by two 90 horse power Ingersoll return tubular boilers. The Ingersoll "Straight Line" air compressors and "Eclipse" drills are here used; and so well thought of are the products of the Ingersoll Company, that on the line of the aqueduct there are now in use 200 drills, 18 compressors, and 30 boilers of their make. The air compressors at shaft 10 have 18 by 30 inch cylinders, supplying air at 80 pounds pressure per square inch, the air being first discharged into a condensing air receiver, where it is freed from all moisture, and then conducted down the shaft and into the headings through 3 and 3½ inch pipe. Each heading is driven by four 3½ inch drills, mounted two on one column, to which they are attached by means of swinging arms, which can be moved up and down or around the column; thus with two columns and four machines, the entire face is commanded at one setting of the columns. From 19 to 20 holes, 5 to 6 feet deep, are drilled for the center cut and squaring up. Two drills, mounted on tripod, drill from three to five holes 8 feet deep in the bench, some being vertical and others flat or lifting. The holes are then charged with No. 1 giant powder in the cut and No. 3 in the side and bench, and exploded by electricity.

The foremen are required to have a round of holes drilled and blasted once each shift of ten hours, it being left to their judgment to decide the depth of cut they shall undertake to drill, square up, and blast in that time. By this method an average of about ten lineal feet of tunnel is completed every twenty-four hours in each face through very hard gneiss and granite. This is a higher rate of progress than is attainable by the deep cut system, which does not permit of each shift finishing its own work.

Extending down the shaft is a rough-looking square wooden box, which branches at the bottom, one part extending along the tunnel to one heading, and the other part to the other heading. At the bottom of the vertical portion, exhaust steam is admitted; this produces a strong current along the branches and up the shaft. The



THE NEW AQUEDUCT TUNNEL FOR THE CITY OF NEW YORK.



MAP AND PROFILE OF THE NEW AQUEDUCT FOR INCREASING THE WATER SUPPLY OF NEW YORK CITY.

smoke resulting from each blast is thus drawn into the boxes and delivered at the top of the shaft.

Where the aqueduct is under pressure, special provision is made in the manholes for guarding against the upward pressure, and drain pipes are provided for emptying the shaft and air pipes for the escape of air during the refilling of the tunnel. A general idea of the construction of one of these shafts may be obtained from Fig. 7, which is a section at right angles to the line of the aqueduct.

Fig. 2 is a view of the work as it now appears at the Potantico cut—the most extensive on the line, as it has a length of about 1,800 feet. The aqueduct here is similar in section to one in rock, as may be seen by comparing Figs. 4 and 5. It has a clear height of 13·53 feet and an extreme width of 13·6 feet. The arch is 12 inches thick at the crown, 16 inches thick at the center of the sides, and 20 inches thick at the spring lines. The concave sides are 8 inches thick, and are secured by walls, as shown in the cut. The invert is 12 inches thick, and rests upon a concrete foundation.

At 135th Street a gate house will be located. Contracts have been let for all the work, with the exception of this gate house and the inverted siphon under the Harlem. The Quaker Bridge project has not yet been definitely settled upon. The contracts have been awarded as follows: Sections A and B to Mr. Heman Clark for $2,147,740; sections 9, 8, 7, and 6 to Messrs. O'Brien & Clark for $4,445,447; sections 5, 4, 3, and 2 to Messrs. Brown, Howard & Co. for $5,297,155; and the gate house at Croton Dam to Messrs. Smith & Brown for $442,000. On the 24th of October the total length of tunnel completed was 22,342 feet, and at the present time the excavation is growing at the rate of one mile per month.

The engineer corps is composed of the following named gentlemen: Mr Benjamin S. Church, chief engineer; Mr. A. Fteley, deputy chief engineer; Mr. H. S. Craven, constructing engineer; Messrs. Charles S. Gowen, J. B. McIntyre, J. W. Wolbrecht, Alfred Craven, E. S. Gould, F. W. Watkins, and E. Wegmann, Jr., division engineers; Mr. F. S. Cook is in charge of the draughting bureau.

CHARCOAL AND COKE AS BLAST FURNACE FUELS.

A PAPER presenting some points in a new light has been contributed to *Stahl und Eisen* by Mr. E. Belani, of Hieflau, on the comparative value of charcoal and coke as blast furnace fuels. With the object of illustrating the points involved, Belani chose soft fir charcoal as used in the Styrian charcoal furnaces, weighing 140 kilogrammes per cubic meter, and Miroeschau (Bohemia) coke, weighing 420 kilogrammes per cubic meter. Assuming both parts to consist of pieces of equal size, viz., spheres 70 millimeters in diameter, 420 kilogrammes of coke would possess a surface of 45 square meters, while the same weight of charcoal would possess a surface of 135 square meters. Thoerner has found that Styrian charcoal has a cell volume of 264 cubic centimeters per gramme, while the average with coke is 50·2 cubic centimeters. These figures Belani adopts. Now, charcoal possesses the peculiarity that a large surface is added to it by fissures. Belani measured these fissures, and found, as an average of a large number of samples, that the additional surface thus presented is equal to the surface of the pieces of charcoal themselves. With these data, he has computed the following as a fair comparison of the surface presented to the blast by 100 kilogrammes of coke and of charcoal:

	Coke. Square Meters.	Charcoal. Square Meters.
Outer surface	10·7	32·1
Cell surface	24·1	126·7
Fissures	—	32·1
Total	34·8	190·9

The surface of charcoal is, therefore, 5·5 times as great as that of coke.

The second point to be determined is the comparative facility of ignition, and that Belani attempted to ascertain by burning equal quantities of both fuels, in pieces of as nearly equal size as possible, in a shaft furnace, noting the time it took to consume both. In one case he found that the ratio was 1·4 to 1 in favor of charcoal; in a second, the average of three tests, the ratio was 1·6 to 1. He adopts 1·5, and states that, while this is surprisingly small, it may be larger with different grades of coke. The product of the comparative surface development and of the facility of combustion may represent the relative value of the two fuels, the ratio being 1 to 8·25. It is evident that, since the surface of equal weights of the two fuels is incapable of any change, the only means available to approach them is to increase the rapidity of combustion of the coke. This means is afforded by the pressure of the blast. It is true that it is not definitely known that the rapidity of the combustion increases directly in the same ratio with the increase of the pressure of the blast, but indications point in that direction. Thus, if a 2 lb. pressure is the maximum in Styrian furnaces, the same rapidity of combustion could be reached in a coke furnace only by blowing at 8·25 times the pressure, or 16·5 lb., in order to make the consumption of fuel equal in both cases. Such a pressure is not practicable, and, therefore, another means is adopted, viz., the use of a greater quantity of the denser fuel, and this, Belani urges, is the true reason why coke furnaces must consume more fuel than charcoal furnaces. Such an increase in the quantity of fuel used has two advantages. A greater surface is created for the attack of the blast, and the quantity of ore in the unit of space is diminished, thereby decreasing the calorific requirements. On an average the increase in the consumption of fuel in making mill iron of coke over charcoal is 40 per cent., that is, for the same weight of charge, the surface of the coke is increased by 40 per cent. The surface exposure to blast was computed in the case of coke at 34·8 square meters per 100 kilogrammes, therefore, 140 kilogrammes would have 48·72 square meters, or the ratio to charcoal (with 190·9 square meters per 100 kilogrammes) would be decreased from 1 to 5·5, as above, to 1 to 3·9. This would admit of a reduction of the blast pressure to 11·7 lb., and yet allow of producing the same rate of combustion

as 100 kilogrammes of charcoal would have with 2 lb. pressure.

If coke and charcoal could be made to work at the same rate of combustion, the charge per cubic meter would be :

	Charcoal. Kilogrammes.	Coke. Kilogrammes.
Fuel	115	230
Stock	314	620

This shows a ratio of weight of stock per unit of space of 1 to 2. Now, by increasing the fuel quantity by 40 per cent., the figures for cubic meter of volume would stand :

	Charcoal. Kilogrammes.	Coke. Kilogrammes.
Fuel	115	290
Stock	314	550

The ratio of weight of stock has declined to 1 to 1·75, and for cubic meter of volume 70 kilogrammes of stock have been taken off. The heat requirements are thereby reduced 25 per cent., and, as a slower rate of combustion is allowable, the pressure may be reduced from 11·7 to 8·78 lb.

The pyrometric effect of coke is greater than that of charcoal, and, since it is a question of temperature, coke possesses certain advantages. The pyrometric effect of charcoal is 2,104, that of coke 2,774, or a ratio of 1 to 1·3 ; therefore a further reduction in the pressure from 8·78 to 6·18 may be made. In a coke furnace the materials lie more densely than they do in the charcoal furnace. For the charges given above, the open space per cubic meter of charge is computed at 0·58 cubic meter for the charcoal furnace and 0·44 cubic meter for the coke furnace. This leads to high pressure in the latter, causing an elevation of temperature. The lower loss by radiation, referred to unit of cubical contents, is another fact which diminishes the necessity for a rapid rate of combustion, and causes a further diminution of pressure to the figures actually prevailing in practice.

While increase in pressure is one means of increasing the rate of combustion, heating of the blast is another one. If the usual higher pressure and the usual increase of surface by additional fuel combine to create in a coke furnace a rate of combustion equal to that in charcoal furnaces, then the addition of another factor operating in the same direction will allow of some reduction of the others. Thus the surface development may be reduced by taking off from the additional amount of fuel, added simply to carry the rate of combustion up to the standard of that of charcoal due to its peculiar structure. This Belani claims is the true reason for the saving of fuel due to the use of hot blast, and it explains, too, why the employment of hot blast tells more in fuel economy in the coke furnace than in charcoal furnaces. Charcoal, which has a high rate of combustion, even with cold blast, reaches its maximum even at lower temperatures, while with coke high heats only begin to develop an approach to the maximum rate of combustion. The denser the fuel, the greater will be the fuel economy through the use of high pressures and hotter blast, the more will the low consumption of the charcoal furnaces be approached. Belani undertakes to explain other phenomena on the same general theory. The most interesting question is that why the quality of the pig produced in the charcoal furnace is better than that of the coke furnace. He holds that it is due to the higher temperature at which the reduction proceeds, carrying more impurities into the iron in spite of the probable fact that in the coke furnace the pig iron goes through a partial fining process while passing the tuyeres.

TROUVÉ'S SIREN.

THE speed of 6, 7, 8, and 9 miles an hour reached by Mr. Trouvé's small electric boats has determined the inventor to provide the latter with an alarm signal or siren, S, thoroughly adapted to this style of navigation. Fig. 1 shows one of these boats, with a portion of one side removed, in order to allow the internal arrangement to be seen.

The motor and the commutator for changing the direction of the boat's running are shown at the bottom of the same figure.

The signal operates through a whistle, S, placed under one of the seats and communicating with the belt, A, of the siren through a rubber tube, T, the length of which is variable. Up to the present, the voice of the steersman has been insufficient to prevent disastrous collision between boats, and this led to the invention of the device under consideration, which produces a sound that may be compared to that emitted by the well-known steam sirens with which large ocean steamers are provided. Mr. Trouvé's siren differs absolutely from all others. Its first sound is a hoarse vibration, which afterward passes quickly through the entire gamut, and finally ends in a prolonged, strident, sharp, loud note.

As all skiffs are not electric ones, Mr. Trouvé has modified the apparatus so that it can be applied to any pleasure boat. In this case it is actuated by the wind.

Mr. Trouvé has also devised a reduced model of this siren, that may be used as a hand signal. In this form it subserves a twofold purpose, being capable of serving at the same time as a cane or umbrella handle (Fig. 2). It is only necessary to blow into the cane or umbrella handle to obtain the sound which is characteristic of steam sirens, and which, by the fullness of its sound, resembles the bellowing of a cow.

FIG. 3.

Apropos of Mr. Trouvé's electric boats, Mr. Nabat, the owner of two of them, in some recent experiments upon the Marne, easily obtained speeds of from 8 to 8½ miles per hour. These boats were of quite respectable size—one being of one ton and the other of two tons. In the case of a 26 foot boat constructed for Vicomte de Dampierre, the owner obtained a speed of 15 miles per hour.

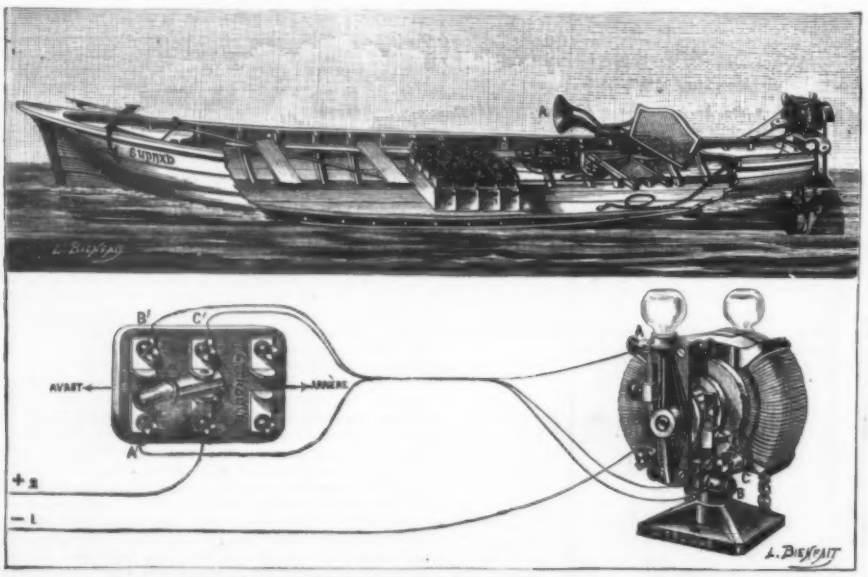


FIG. 1.—TROUVÉ'S ELECTRIC BOAT, MOTOR, AND COMMUTATOR.

An electric light is placed in the bow, and, thanks to this and to the siren under consideration, collisions are rendered impossible.—*Chronique Industrielle.*

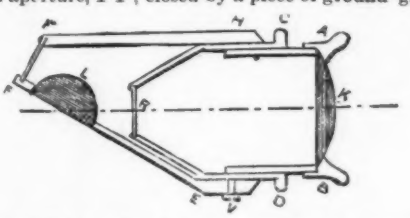
BERTRAND'S REFRACTOMETER.

THE quick analysis of solids and liquids is a subject that deeply interests not only the physicist, chemist,

FIG. 2.—TROUVÉ'S PORTABLE SIREN.

and mineralogist, but also all those who wish to find out almost instantaneously the nature of a material for an industrial or commercial valuation. The distinguishing of precious stones from each other, especially, is a delicate operation, and one that requires to be done quickly, although an error may lead to grave consequences. Mr. E. Bertrand has recently devised a small apparatus which he calls a refractometer, and which answers these difficult requirements. The apparatus is but 2 in. in length by 1 in. in diameter, and comprises an eyepiece, a reticule tube, and a cylindrical box. The eyepiece, A B, consists of a copper tube, to the upper part of which is screwed a collar that holds a crown glass lens ¾ in. in diameter and of 1¼ in. focus. This eyepiece slides with slight friction into the reticule tube, C D R, which at its lower end is conical, and carries a reticule, R. This latter consists of a glass disk ¼ in. in diameter, provided in the center with 80 divisions $\frac{1}{75}$ of a millimeter apart, and numbered by tens. These two parts slide into a cylindrical box, E, F, F', H, consisting of a tube cut at one extremity according to a plane that makes an angle of 30° with the axis. Upon this elliptical section there is fixed by screws a copper disk which carries a hemispherical lens, L, of flint glass, and of ½ in. radius. The plane surface of this lens corresponds to the external surface of the disk, and its center is in the axis of the apparatus.

An aperture, F F', closed by a piece of ground glass,



permits light to enter at the end opposite the eyepiece. At V there is a screw that serves to hold the reticule tube in place, after it has been regulated, so as to keep the reticule in the focus of the lens, L.

So much for the apparatus; now let us see how it gives the index of refraction of a substance. Let us suppose that we have put a drop of liquid upon the plane face of the lens. Then, the luminous rays, entering the lens, will undergo a refraction due to their passage from the air into the glass, and will reach the surface of the liquid. Of these incident rays, some will enter the liquid, and others (those which make an angle greater than the extreme one, F, with the perpendicular to the point of incidence) will undergo a total reflection, and light up the lower portion of the reticule, while the upper portion, which receives no luminous ray, will remain dark. The line of separation of these two regions will vary with the limiting angle, and as this latter depends upon the index of refraction, it may be readily seen that the position of this line will give the index of the liquid submitted to experiment if the apparatus is properly graduated. We shall, then, read upon the scale the division through which this line passes, and this latter will be so much the lower in proportion as the index, n, is greater, since F increases at the same time with n. So much for liquids.

With solids the principle is the same, and the operation is as follows: We place a plane and polished part of the object against the lens, and interpose a little liquid of an index higher than that of the solid, since a total reflection cannot occur on the surface of separation of two substances unless the luminous rays are passing from one refracting medium into another that is less so. Upon looking into the apparatus, we shall see two lines—one corresponding to the index of the solid, and the other to that of the liquid. It is the former of these whose position must be read upon the graduated scale. It would be impossible to confuse the two, since the liquid used is determined in advance.

In order to graduate the apparatus, the indices of the different liquid or solid substances are accurately determined, and then it is ascertained what divisions of the reticule correspond thereto. After this a table is prepared that gives the index corresponding to each division.

In giving the method employed with solids, we remarked that the immersion liquid must have an index greater than that of the substance to be studied. For bodies of low index, such as fluorspar, oil or benzine may be used. For those of a higher index, it is well to employ dibromated naphthylphenylacetone. This substance, which was discovered by Mr. L. Roux, has

an index of 1·7, and may consequently be used for almost all solid bodies, for there are but a few whose index exceeds that of this. Mr. Bertrand in using it adds to it a few drops of bromated naphthalene, which lowers its index but slightly, and renders it completely liquid.

In order to fully appreciate the real value of this new instrument, and to understand its advantages and simplicity, it will suffice to recall the "Newton method" that is generally employed for measuring indices. Here, if it is a solid body, we give the specimen the form of a prism, and measure the angle, A, of the latter, and obtain the value, D, of the minimum deviation. After this we calculate the index, n, by means of the formula:

$$n = \frac{\sin \frac{D+H}{2}}{\sin \frac{A}{2}}$$

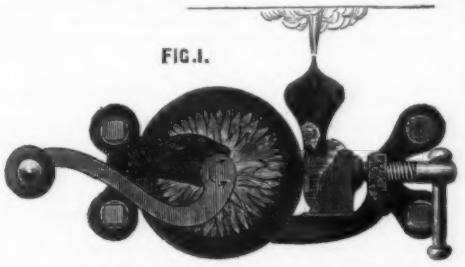
These operations necessitate the use of complicated instruments, certain notions of mathematics and physics, and lengthy calculation. With liquids the difficulty is still greater; moreover, this method cannot be applied unless we have on hand a sufficient quantity of the substance to use at our will.

The refractometer, on the contrary, furnishes the index upon a simple reading, and without the necessity of breaking or destroying the object. It gives the two first decimals accurately, and even the third within about two or three units—this being a sufficient approximation in many cases. It can be used with advantage by jewelers and lapidaries, since it permits of distinguishing genuine from imitation stones, owing to the difference in their indices.—*Le Genie Civil.*

MAKING STEAM BY FRICTION.

THE friction still illustrated by the accompanying engravings has been devised, says the *Engineer*, by Mr. Lional Pearse, of Coalbournbrook, near Stourbridge, for the production in an open boat, or in any boat at sea, of small quantities of fresh water from sea water without any heat supply except that of muscular energy. The still and the small machine for illustrating the frictional generation of heat are very ingenious applications of well known phenomena and of the experiments of Count Rumford. Mr. Pearse has succeeded

FIG. 1.



in solving a problem which has occupied many minds; and although no vessel expects to be wrecked, there is little doubt every well-appointed passenger ship will carry several of these little machines for their boats.

Fig. 2 shows a friction still fixed to and let through the seat or after thwart of a ship's boat; above that seat is the condensing or domed part, and below is the malleable iron framing. The machine may, of course, be fixed to any, or the most convenient, place in a boat. Our engraving is about one-fourth full size. The framing may be said to consist of two parts, one fixed and the other movable; the fixed frame, F, being bolted through the seat, fixes the part above the seat to that below. The metal supporting the boiler must be understood to be part of this fixed frame, though the section does not clearly show it. The movable frame, M, is capable of a sliding motion in three bearings, one above the pressure screw, S, and another to each side of friction wheel, W. It is single where shown in section, and branches off to each side of the wheel to form bearings for the spindle, P. This frame brings the friction wheel, W, in contact with the boiler, B, at B^1 with any desired pressure, regulated by the pressure screw, S.

The inequalities which may occur in the periphery of the friction wheel are compensated for in the elasticity of the packing at E. Either side of the spindle may be fitted with a handle, and the same still can be worked effectively within the range of power from that of a lad of fourteen years of age to 4 man power. The boiler, B, is held in a hard wood block to prevent heat being readily conducted to the metal frame supporting it. The upper part of the machine is hinged at H, and may be thrown open, leaving boiler and friction wheel exposed; the inner domes, D^1 D^{11}, also hinge open or take out for any attention that may be required.

The overflow tank, T, is pivoted so as to be easily released from the boiler. The manner in which it is fed and the action are as follows: It will be seen that the upper tank, A, is full of sea water; from this tank the water is made to pass at intervals in the directions indicated by the arrows. It then passes down small pipes shown in the center, and feeds or saturates the flannel with which the two domes are covered. The arrows still indicate the course of the sea water after it has left the coverings, and it will be seen that that from the inner dome, D^{11}, as it is collected by its trough, runs through a pipe into the overflow tank, T, which tank is openly connected with boiler, B, keeping that fed with sea water to the height allowed by overflow tank; the overflow from the middle dome, D^1, is allowed to run away as cooling water, because that from the inner dome is sufficient feed for the boiler, and, being hotter than that from D^1, is preferred. The water enters the boiler at the bottom, as shown by the arrow. The heat result of the friction of the wooden wheel, W, against the steel on the boiler at B^1 causes the sea water to boil in about half a minute. The steam then rising is wrapped in the dome, D^{11}, and, condensing upon its inner surface, drains away into its trough, then from that to the outlet pipe, P. The condensed steam or distilled water may be traced throughout the engraving indicated as drops.

The heat given up by the steam condensed upon the inner surface of dome, D^{11}, will be imparted to the sea water held in the saturated flannel covering the dome, D^{11}; this water is freely vaporized at a lower temperature than that required for the boiler, its vapor being condensed upon the inner surface of dome, D^1, inclosing it. The action of vaporizing and condensing goes on in the next compartment, as just described, but at a lower temperature; the product from the three condensing surfaces can be traced as drops all flowing into and out of outlet pipe, P. The feed water, W, in the tank, A, will, when the machine is in full work, reach a temperature that a delicate hand cannot bear by heat imparted to it from the vapor which condenses upon the domed bottom of the tank.

If the machine is worked by the power of a boy of fourteen years, the product from the two flannel-covered domes will be nearly double that of the boiler; if worked by a man, the product from the boiler will be equal that of the two domes, making the profit through the domes upon the man's work much less in proportion to that of the boy's work. Covered domes may be used with profit to any convenient number, but, on account of size, the inventor prefers to put only three in the friction still. In its present form the still is capable of producing thirty pints of distilled water in twenty-four hours, sufficient, he thinks, for any small boat's crew. Salt will not, we are informed, appear deposited if the machine is used properly, or unless all in the boiler or in the domes is vaporized to dryness.

Should this occur—and it must occur many times before sufficient salt is incrusted to cause any serious loss of heat—it can be got at by throwing the top open and releasing the overflow tank. The domes are cleansed by allowing a quantity of water to flow over them when not at work. The inventor explains the non-appearance of salt in the boiler and on the flannels by saying that, in the case of the flannels, all the water fed to them is not vaporized; thus the salt is kept in solution, and is carried off in the water as it runs to waste or to the overflow tank. The boiler does not show any because of the overflow tank, which is always wasting water, and its water being nearly as heavily charged with salt as that of the boiler, because a certain amount of circulation goes on between them; so the salt is kept at an equilibrium, regulated by the salt carried away in the overflow. The hard salt that does appear is only found on the outside of the overflow tank, TT. So long as the evaporation in the boiler is not allowed to empty it, no salt appears there.

Fig. 1 of our engravings shows another arrangement by the same inventor for utilizing friction as a mode of heat. As this is not like a still—a thing treating of life and death—he has thought fit to make it rather fantastic, and his design carries us back many ages. A single casting, taking a snake-like configuration and the necessary course, forms the whole of the frame; a sliding box carries the wood in which the boiler is mounted; the spindle of friction wheel has one bearing in the mouth of the creature and another in the frame at the opposite side of the friction wheel; the radiating frame piece or wheel boss is in one piece with the spindle or is fixed thereto, the purpose of it being to fix the wooden wheel; an ordinary handle and bolts complete the machine, the boilers for which may have various sizes or shapes, according to purpose.

The inventor devised it as specially suitable for lectures on physics, for use in magazines where fire is not allowed, or for heating shaving water, where half a minute's vigorous work every morning serves the purpose of providing a little hot water for this purpose, waking the shaver up, and providing him with exercise which is better now than in July.

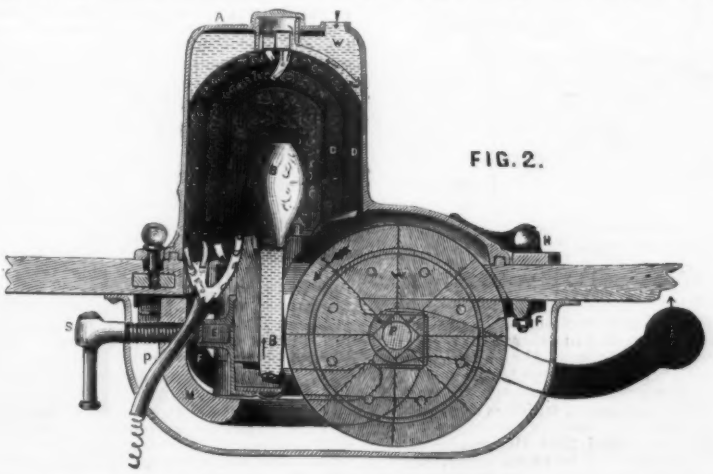


FIG. 2.

MAKING STEAM BY FRICTION.

[NATURE.]

AN IMPROVED FORM OF TEMPERATURE REGULATOR.

IN 1882, at the request of the Board of Trade, the Royal Society appointed a committee, consisting of Sir G. Airy, Col. Clark, and Prof. Stokes, to advise on the question of improving the existing means of the comparison of standards of length at the Standard Office. In their report the committee suggested improvements in the arrangement for securing greater uniformity and steadiness of temperature in the bars under comparison. As a first step in this direction, the Cambridge Scientific Instrument Company were requested to investigate the subject of temperature regulators, and to consider the general design of a comparing apparatus.

They proposed that the standards, some hours before they were observed, should be placed in metal cases and immersed in a bath containing water; and that they should not be disturbed during the process of observation. If the uniformity of temperature of the water could be insured, it would secure the equality of temperature of the standards, and remove one of the greatest difficulties in the construction of a satisfactory comparing apparatus.

After some preliminary trials, a regulator was constructed similar to that used at the Bureau International des Poids et Mesures at Sevres.* Its action depends on the variation of pressure of a saturated vapor, caused by a change of temperature. The pressure on the volatile liquid and vapor is due to the atmosphere, as well as to a column of mercury; consequently the regulated temperature will vary with any change in the atmospheric pressure. In the following experiments the corresponding change of temperature for

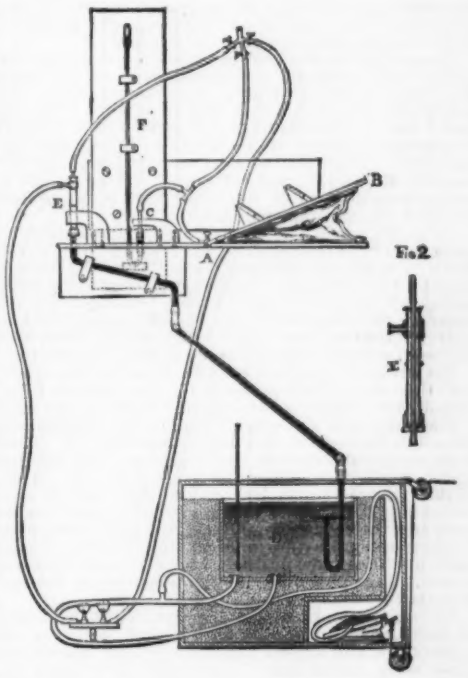


FIG. 2.

one inch alteration of the barometer was about 0·37° C. The accuracy of the regulator therefore depends on the constancy of the atmospheric pressure, and to overcome this serious disadvantage an arrangement was devised for maintaining a constant pressure on the volatile liquid.

An iron bath, D (Fig. 1), containing water, was placed in a wooden box. The intermediate space was filled with sawdust; this was done to minimize the unequal cooling due to the varying temperature of the room. The two ends of a U-shaped tube were fixed into the bottom of the iron bath and passed through holes in the side of the wooden box. The water was kept warm by means of two gas flames placed under a part of this tube. One of the gas flames was connected to the regulator, and the other direct to the gas main. The object of the second flame was to relight the regulated gas jet in case it should have been extinguished by the regulator.

The water in the bath was kept thoroughly stirred by air forced through it by means of bellows. These were placed inside the box in order to keep them warm, and also for the more important reason of avoiding the currents of air which would otherwise be produced at each stroke. The air used for stirring was thus saturated with aqueous vapor, and did not cool the water in the bath by absorbing moisture from it.

The nozzle of the bellows was connected to the U-shaped tube by a branch inserted just above the point where the gas flame was applied. The air thus pumped through the upper part of the U tube caused a rapid circulation of water through it. This method has the advantage of applying the heat in a manner which does not tend to make the water in one part of the bath perceptibly hotter than the rest.

The volatile liquid in the regulator was a mixture of methyl-chloride and ethyl-chloride, boiling at about 2⅛° C. under the normal atmospheric pressure. It was contained in a flat bulb, G, blown at the end of a glass tube, and was under a head of mercury. The glass tubes containing the mercury were connected by short lengths of canvas-lined India rubber tube. A double brass tube was secured to the open end of the regulator, E. This is shown enlarged in Fig. 2.

The gas entered by the inner tube, which passed down to the surface of the mercury, and the outer tube

* See "Travaux et Memoires du Bureau International des Poids et Mesures," tome i., p. C. 10.

was connected with the gas burner placed under the U-shaped heating tube. Thus a rise of mercury in the regulator reduced the supply of gas to the burner. The cross section of the flat glass bulb, at the common surface of the mercury and volatile liquid, was large compared with the cross section at the upper end of the regulator. Thus nearly all the increase in height, due to expansion of the volatile liquid and vapor, takes place at the upper end of the regulator, and the level of the common surface of the mercury and volatile liquid remains nearly constant.

The most interesting part of the apparatus is the arrangement for compensating for the variation of atmospheric pressure. With this object a barometer in the form of a bent tube is fixed at F. To simplify the explanation, we will suppose that the atmospheric pressure diminishes by an amount equal to a head of one inch of mercury; this will cause the mercury in the open end of the barometer to rise half an inch. If the regulated gas flame is to be extinguished when there is a constant pressure on the volatile liquid, then the tube, E, must be raised one inch; thus it must move in the same direction as, and twice the amount of, the exposed surface of the mercury in the barometer.

To accomplish this, the upper part of the regulator was attached to a board turning about a horizontal axis, A. A gas bag was placed between the projecting end of this board and a fixed board, B. The board turning about A was so weighted as to tend to close the bag. The nozzle of the bag was connected to the gas main, and a branch pipe led to a small tube, C, passing down the open end of the barometer. This small tube was fixed by a bracket to the movable board half way between the upper end of the regulator and the pivot, A. Now, if the mercury rises in the open end of the barometer, it closes the tube, C, and the gas from the main passes into the bag, forces the boards apart, and raises both the upper end of the regulator and the tube, C, until the escape restores the equilibrium. The flexible India rubber connections in the glass tubes allow the necessary movement to take place. This arrangement is of interest, as the pressure of the gas supply is the motive power for automatically moving a piece of mechanism in a required manner.

The apparatus was kept in action for fourteen days without readjustment, but the stirring of the water was discontinued at night. The thermometer was read about ten times a day, and from July 18 to August 1 the extreme readings were 30·90° C. and 30·86° C. The greatest change of temperature during any day was 0·04° C., the least observed change during any day was 0·01° C., and the longest period during which no change was observable was from 12:30 P. M. on July 20 to 1 P. M. the following day.

At night, when the stirring was discontinued, the variation of the temperature was greater, but it settled down to its normal amount shortly after the stirring began. In a properly constructed comparing room the change of temperature would have been less. On one occasion the barometer rose rapidly, nearly half an inch in twenty-four hours, and during this time the temperature of the water did not vary perceptibly. If the barometer had not been attached to the regulator, this change of pressure on the volatile liquid would have produced a change of 0·14° C. in the bath.

The apparatus was roughly made in an experimental form, but the results were highly satisfactory. There were, no doubt, errors in the readings of the thermometer. Sir William Thomson, in his article on "Heat" in the "Encyclopædia Britannica," describes an error which may be introduced owing to the mercury in the stem of a thermometer remaining at rest while slight changes of temperature are occurring, and then moving suddenly into a new position, where it again remains at rest. This phenomenon was observed in the very delicate thermometer used.

The variation of temperature due to the expansion of the mercury in the barometer and regulator was perceptible, and agreed roughly with the amount arrived at by calculation. Very small errors were also probably introduced by the following causes: the sticking of the mercury in the regulator and the barometer; variation of the gas pressure; imperfections in the mechanism and of the vacuum in the barometer.

There can, however, be little doubt that the errors produced by these and other causes could be reduced to an inappreciable amount; and if the apparatus were placed in a room of fairly constant temperature, remarkable results could be obtained.

HORACE DARWIN.

[Continued from SUPPLEMENT, No. 557, page 8894.]

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

By Prof. C. W. MACCORD, Sc.D.

NO. IV.—THE CYCLOID.

IT may be shown in a very simple manner that the evolute of the common cycloid is an equal cycloid, and that its radius of curvature at any point is twice the generating chord at that point.

In Fig. 15, let JJ be the common tangent at O of the two equal circles whose centers are C and I; let *pOd* be perpendicular to TT, and *NdN* be tangent to the lower circle. Then if the upper circle roll upon TT, and the lower one roll upon NN, as indicated by the arrows, the point *p* will trace the cycloid *p*PBS, and the point *d* will trace the equal cycloid *d*DRS. Supposing the two circles to roll at the same rate, the two curves will be described in the same time, the two circumferences will always be tangent to each other at some point of TT, and the two marking points will reach S at the same instant.

Set off on the upper circle any arc O*a*, and on the lower one an equal arc *dm*; and on the tangent lines set off OA, *d*M, distances equal to these arcs. Then when the upper circle has rolled along TT through the distance OA, the point *a* will have reached A, the radius C*a* will be the contact radius EA perpendicular to TT, and the chord *ap* will be the generating chord AP, which is normal to the cycloid at P, because A is the instantaneous axis at that position of the rolling circle. In the mean time, the lower circle having rolled through an equal distance, the radius I*m* will be the contact radius HM, perpendicular to NN, and the chord *md* will be the generating chord MD, normal to the lower cycloid at D; and DA perpendicular to it will be tangent to that curve at the same point. Since *d*M = OA, MH and AE will lie in one right line, which produced cuts the upper circle in G; and GP will be equal to O*a*, because AP is equal to *ap*. GP is therefore equal to MD, the two triangles GAP and MAD are similar and equal, and since MAG is a right line, PAD will also be a right line, bisected at A. And since PD is tangent to the lower curve at D, and normal to the upper one at P, it is, evidently, the radius of curvature of the latter of which the former is the evolute, as at first enunciated. In like manner, when the circle has rolled so far that *p* reaches B, it may be shown that BR will be the radius of curvature at that point, and so on.

The line of argument here adopted depends upon an assumption which, although it is so nearly self-evident that it is scarcely likely to be challenged, is nevertheless susceptible of proof, viz., that in rolling contact the instantaneous axis passes through the point of tangency. If in Fig. 16 the lower of the two curves in contact at A be regarded as fixed, it is easily comprehended that the point A must be the fulcrum about

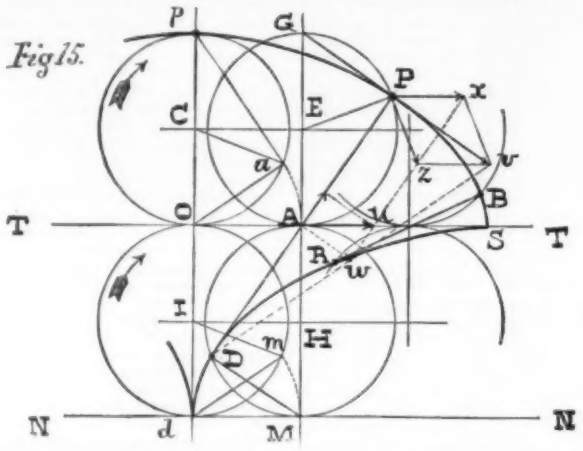


Fig 15.

which the upper one is at the instant turning. Still, there may be some who would prefer a more rigid demonstration, which may be made as follows:

Let C, D, be the centers of curvature at the point A, and let P be any point rigidly connected with the upper or rolling curve. If this upper curve rolls in the direction indicated by the arrows, this rolling may be considered as the resultant of two motions—one, a rotation about center D, as shown by the arrow *r*; and one, a circular translation about center C, indicated by the arrow *s*. Let the first of these give to the point A a motion to the left of any velocity *m*, indicated by A*x*; then the second must be of such magnitude as to give the point A a motion to the right of the same velocity *m*, as indicated by A*z*.

Draw PA, PC, PD; then, since P is rigidly connected with D, the motion of rotation will cause P to move in a direction perpendicular to PD, while the motion of translation will cause it to move perpendicularly to PC.

We shall then have—

$$\left.\begin{aligned} PH &= m\,\frac{PD}{DA} \\ PE &= m\,\frac{PC}{CA} \end{aligned}\right\} \therefore \frac{PH}{PE} = \frac{PD \,.\, CA}{PC \,.\, DA}$$

Draw AN parallel to PC, and AK parallel to PD. Then—

$$\left.\begin{aligned} \frac{PN}{PD} &= \frac{AC}{CD} \therefore PN = \frac{PD \,.\, AC}{CD} \\ \text{Also—}\quad \frac{PK}{PC} &= \frac{DA}{CD} \therefore PK = \frac{PC \,.\, DA}{CD} \end{aligned}\right\} \therefore \frac{PN}{PK} = \frac{PD \,.\, CA}{PC \,.\, DA}$$

Consequently $\frac{PH}{PE} = \frac{PN}{PK}$, but the angle HPE = angle NPK, whence the completed parallelogram PHIE is

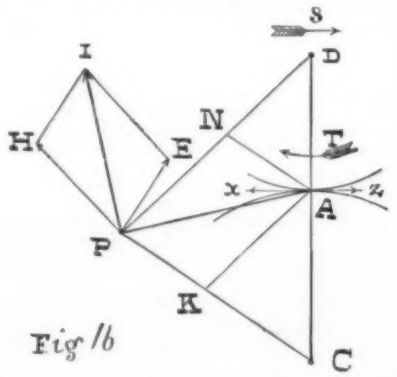


Fig 16

similar to the parallelogram PNAK, and drawing the diagonal PI, we have the angle IPE equal to the angle APC; then—

EPA + IPE = IPA is equal to EPA + APC = EPC, = 90°.

But PI is the resultant motion of P due to the rolling; and its direction is thus shown to be perpendicular to a line drawn through P and the point of tangency A; and CD, which by hypothesis is perpendicular to both the assigned motions A*x* and A*z*, passes through the same point, which is consequently the instantaneous axis.

It may possibly be objected that the course of proceeding outlined and pursued in previous articles has here been abandoned; to which it might be rejoined that there is no need of traveling a circuitous road if a more direct one can be found. Still, it may be as well in this case to show that the other mode of treatment would have given the same result. Considering the compound nature of the motion as just explained, we can draw the tangent to the cycloid by Roberval's method, thus: For the motion of rotation draw, in Fig. 15, P*z* perpendicular to EP, and for the motion of translation draw P*x* parallel to TT; these components may be of any magnitude, but from the nature of the case must be equal to each other. Completing the parallelogram, its diagonal P*v* is tangent to the curve, and is perpendicular to AP, as demonstrated in Fig. 16. The instantaneous axis A has a motion in the direction TT, represented by A*u*, equal to P*x*. This motion has a component A*w* perpendicular to AP, and *vw* produced cuts AP produced in D the center of curvature. In order to determine the value of PD, we observe that in resolving A*u*, we draw through *u* a parallel to AP; this produced must pass through *x*, because A*u* is equal and parallel to P*x*, and being perpendicular to P*v*, it must also pass through *z*, because, P*xvz* being a rhombus, its diagonals bisect and are perpendicular to each other. P*v*, then, being twice A*w*, PD is twice AP. Thus the two methods of investigation are seen to give concordant results, agreeing with the deductions of analysis. The radius of curvature being equal to twice the generating chord of the rolling circle, becomes zero at S, and reaches its maximum at *p*, where it is equal to twice the diameter of the circle.

We have confined our attention to the half of one branch of the cycloid, it being perfectly apparent that the evolute of the other half will be similar and symmetrical to the curve *d*DS.

CHEMISTRY OF THE ALKALOIDS.

PROFESSOR JAMES DEWAR, F.R.S., in the course of three lectures upon "The Alkaloids," recently delivered at the Royal Institution, said that the alkaloid department was one of the most recondite of organic chemistry, and for what is known about it the world is much indebted to pharmaceutical workers. The alkaloidal bodies are easily separated, because they form compounds with acids, and in general they exert a violent physiological influence upon the system. At present, chemists are very close upon making them artificially, indeed some of the simplest of them have already been built up synthetically; therefore, if the Legislature exerts itself to stop the cultivation of opium, there is no guarantee that morphia may not hereafter be made artificially. All the alkaloids contain nitrogen, probably in the form of ammonia, from which form there is reason to believe that all alkaloidal bodies are built up. Ammonia has to be heated before it will burn in air. It can also be burnt at low temperatures, for ozone has a remarkable power of attacking it in the cold. Another way of burning it is by means of a hot spiral of platinum in a mixture of air and ammonia, when nitrate of ammonia is formed by the combustion set up. Where do the nitrates come from originally? The inference is that they come from the vegetable kingdom, for when antiseptics are mixed with soils the process of nitrification is stopped. By means of a cold of —80 C., ammonia can be liquefied; it will then dissolve the metals potassium and sodium, and form deep blue solutions of them; afterward it will evaporate from them and leave them as before. The blue solutions transmit the violet and ultra-violet rays, somewhat as is done by thin films of metallic silver. Ammonia is exceedingly healthy to breathe. The lecturer here built up chloride of ammonium synthetically by passing an electric discharge through a mixed atmosphere of hydrochloric acid, nitrogen and hydrogen gases; the newly formed salt then condensed on the sides of the tube. As a test for the presence of ammonium, Professor Dewar allowed one drop of a saturated solution of the chloride to fall into a large jar of water; he then added a little iodide of mercury dissolved in a solution of potash, and a brown coloration was set up. The test, he said, is sufficiently delicate to detect ammonia when dissolved in one million times its volume of water.

In his second lecture, Professor Dewar said that the action which takes place when sunlight acts upon the leaves of growing plants is not accurately understood; but it is believed that a transformation takes place between carbonic acid and water, in some way or other through the agency of chlorophyl. Oxygen is set free, and starch and sugar formed; the sugar seems to be formed before the starch. Plant life is not so economic an engine as might be supposed at the first blush; a large amount of energy seems to do little work in proportion; in the leaf the process is one of reduction, oxygen being removed. Oxalic acid is believed to be formed in the leaf at the same time as starch and sugar; oxalates occur largely in the juices of plants, and within the last few weeks some discoveries have been made tending to prove that oxalic acid is an agent of reduction in the leaf. When oxalic acid is oxidized in the presence of a salt of iron, carbonic anhydride is given off. This is a reversal of the process which takes place in the leaves of plants.

In tracing out the chemistry of the evolution of the alkaloids, the inquirer wants to get nitrogen connected with carbon; cyanogen consists of carbon connected with nitrogen, and is produced synthetically by the electric arc in the presence of air and moisture. Magnesium has the peculiar property of uniting with nitrogen as well as with oxygen, when it is burnt in air. If the magnesium be first moistened, nitrate of magnesium is formed, and ammonia is liberated. Titanium is another metal which has the power of uniting with nitrogen by combustion.

As examples of various classes of products obtained from organic matter by dry distillation, Professor Dewar put some sawdust in one retort, some India rubber in another, and some fragments of quill in a third, then applied heat. The India rubber gave off combustible oily matter, the sawdust gave an acid distillate from the production of ordinary vinegar, the retort half full of cuttings of quill pens gave off a distillate strongly alkaline, consisting of carbonate of magnesia and some basic bodies.

In his third and last lecture, Professor Dewar said that the word "aromatic" conveys an idea to the mind of the modern chemist other than it did to the chemists of earlier times, for aromatic compounds are now recognized as derivatives of benzole. Take away an atom of hydrogen from benzole and substitute one of nitrogen, the pyridine nucleus of the alkaloids is then formed. If aniline be mixed with strong sulphuric acid and some glycerine, quinoline is formed when the mixture is heated, consequently is thus made artificially; the hydrogen in this base does not unite with nitrogen in the form of ammonia. Corrosive sublimate precipitates alkaloidal bodies as a class, and is an excellent reagent; tartaric acid dissolves the alkaloids. The deadly alkaloid brucine has a remarkable reaction with strong nitric acid, a deep red color being produced thereby; sulphuric acid has no apparent action upon strychnine, but if bichromate of potash, an oxidizing body, be also added, a fugitive violet color is produced. All the alkaloidal bodies combine with chlorate of platinum; quinine, for instance, may be taken and acidified with a little hydrochloric acid, then upon adding a few drops of bichloride of platinum, what is called "the platinum salt of quinine" is thrown down; there is a corresponding gold salt, but that of platinum is ordinarily used for the purpose. The alkaloids have remarkable optical properties, which have been worked at by Professor Stokes, many of them being fluorescent. Quinoline exercises a powerful absorption in the ultra-violet portion of the spectrum. Messrs. Macfarlane, of Edinburgh, said the speaker, have manufactured these alkaloidal bodies for nearly half a century.

THE UPWARD PRIMARY BATTERY.

A, Fig. 2, is a glazed earthen vessel containing a porous jar. Inside the porous jar is placed a slab of zinc. Carbon plates, CC, are placed on each side of the porous jar, and surrounded by granular crushed carbon packed and pressed closely together. The top of the carbon compartment of the cell is hermetically sealed by a material of the nature of marine glue—hence, no gas let into the carbon can escape except through the porous jar. The zinc plate in this jar is surrounded by a solution of chloride of zinc. When the cell is required for use, gaseous chlorine enters, or rather is drawn into, the cell by a very interesting arrangement. A lead pipe goes from the top of one cell to the bottom of the next, and the gas passes from cell to cell through these pipes.

The zinc chloride solution which is formed by the working of the battery very slowly percolates through the porous pot, B, into the outer cell, and insures the broken carbon remaining moist; but the tap, T, which is always open, prevents any liquid accumulating in the outer cell; allowing it to run down, F, into the trough below. The level of the liquid in this is always kept above the orifice of the tubes, so that no gas escapes, while an overflow is provided into the house drain. ($ZnCl_2$ is an excellent disinfectant.) The method of supplying the cells with chlorine gas is highly ingenious. The gas arrives from the holders (of which more hereafter) by the tube seen at the left of Fig. 1, where it passes into a bubbling bottle, from which it enters the lower part of the first cell (B 18); the exit at the upper part of this cell is connected by a tube to the inlet at the lower part of the second cell, and so on through all the cells in series; the exit of the last cell being connected by a tube, through another bubbling bottle, to a simple water aspirator or ejector, shown at O, Fig. 4.

Assuming the cells to be all full of gas and the circuit closed, the gas will be equally consumed in every cell in proportion to the current; and, as the carbon cells are hermetically sealed, a vacuum is gradually produced, thus drawing further supplies of gas from the holder. If the chlorine were absolutely pure, no further feeding would ever be required, as the cells would always keep themselves supplied from the holder.

In practice, however, it is not possible to prevent the admixture of a small quantity of air (say 3 per cent.), and a consideration of the conditions will show that this air must first accumulate in the last cell.

The E.M.F. of this last or right hand cell will, therefore, drop before that of the others is in the slightest degree affected, and this drop is arranged to automatically open the aspirator by means of the apparatus shown in Figs. 4, 5, and 6, and to cause the removal of this accumulated air.

The terminals of the last cell are joined to the terminals of a high resistance magnet, A, which, when the E.M.F. of this cell is normal, has sufficient power to pull down its polarized armature, D, and the course of the main current from the battery is from the last cell through the mercury cup, C, armature, D, and pillar, E, to the outer circuit; but when the E.M.F. of this last and master cell falls by reason of accumulated

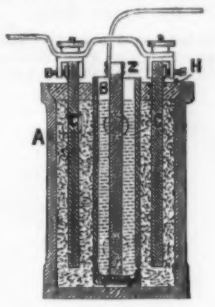


FIG. 2.

air, the armature is released, and contact broken at C, so that the main current has to pass round the large electro-magnet, H, to the outer circuit. The armature, J, of this magnet is then attracted, and opens the adapted "ball valve," I_4, which is normally kept closed by the spring, K; water then enters the aspirator, O, drawing off the air from the last cell, through the tube, P. As soon as the air is replaced by chlorine the E.M.F. of the cell rises again, the armature, D, is attracted, the large magnet short-circuited, and the armature, J, released, so that the water supply and action of the aspirator is stopped.

When the battery is in regular use, the aspirator "goes on" for about 30 seconds, at intervals of from one to three hours, according to the purity of the gas. The quantity of water used is therefore infinitesimal, and there is absolutely no waste either of water or gas.

The form of gas holder which has been adopted, after much experiment with mechanical and liquid sealed holders, is shown in Fig. 7. It consists of several

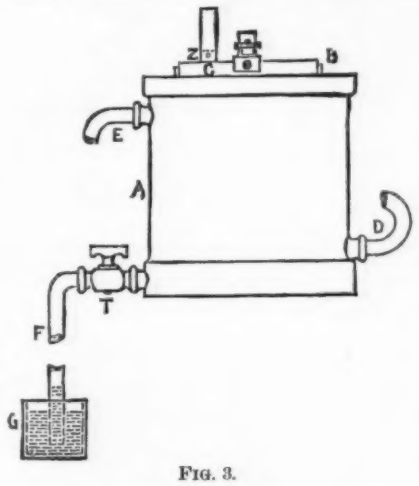


FIG. 3.

columns, made of ordinary earthenware drain pipes, cemented together and tarred on the outside.

The chlorine gas from the generator, which is two and a half times as heavy as air, enters the first column by a tube at the lower end, displaces the air, and overflows through a lead tube to the bottom of the second column, which also becomes filled from the bottom upward; the third and succeeding columns then fill in the same way, the number employed depending on the amount of gas it is desired to store, each column of four 9-inch diameter drain pipes holding gas equivalent to about 460 watt-hours. Each of the lead tubes connecting the columns is provided with a glass bulb painted white at the back, which enables one to see at once how many columns are filled with gas, as the well

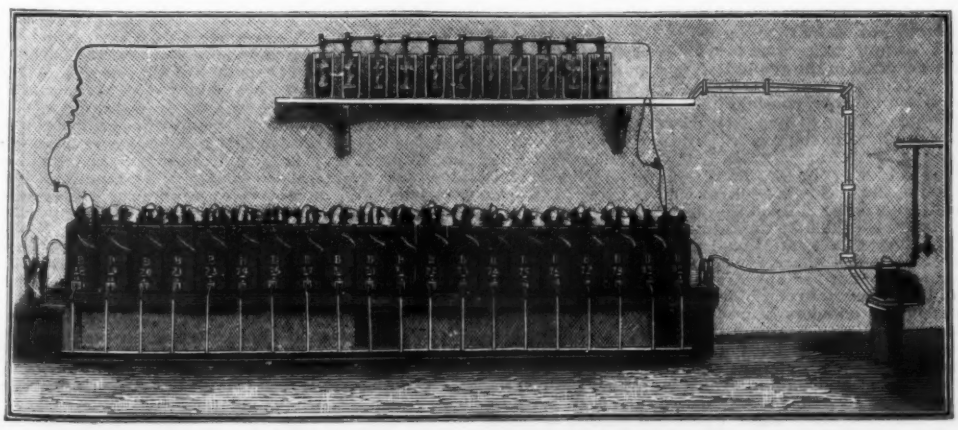


FIG. 1.—THE UPWARD PRIMARY GAS BATTERY.

defined color of the chlorine shows up distinctly against the white background. The last column is provided at its top end with an outlet tube, carried into the outer air.

Up to the present time, the manufacture of chlorine gas has been distinctly an operation to be carried on out of doors, and Mr. Upward fully recognized that, unless the gas could be easily produced in a perfectly inodorous manner, its use for household purposes would be impracticable.

The method adopted is remarkably free from any objection on this score, the whole operation being perfectly free from smell and extremely simple, so that any servant can do all that is required. The generator

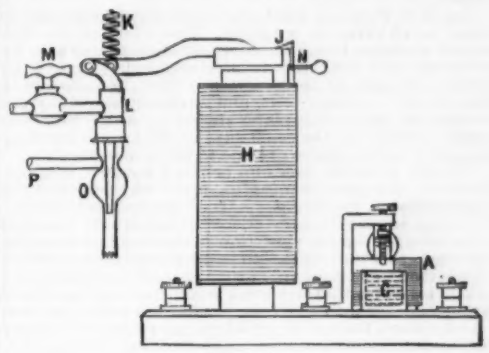


FIG. 4.

consists of a round outer earthenware pan, 18 in. diam. by 12 in. deep, permanently set in a sand bath, which is heated by a small gas jet or small oil flame; the quantity used of such fuel being extremely small. In this outer jar is placed a perforated earthenware vessel, containing a month's charge of manganese, the whole being closed by a cover with a water seal, which makes the generator absolutely gas-tight. In the cover is a funnel, provided with a tap, and when it is required to make gas, the funnel is filled from a vessel containing concentrated brine and from another containing dilute sulphuric acid, and the tap being turned, the contents pass into the generator.

The chlorine generated is led away through a hole in the cover to a bubbling bottle and then to the holder, a branch tube being taken off to the batteries. At the bottom of the outer pan is a tap and pipe to the drain, for emptying the liquid when spent. When the charge of manganese has become exhausted by constant repetition of the above process, the pan is filled, through the funnel, with water, so as to wash it and expel the least trace of gas. The water is then run off, the cover lifted, and the perforated vessel refilled with fresh peroxide of manganese. The replacing of

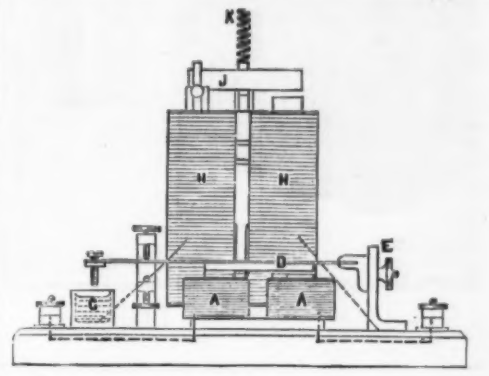


FIG. 5.

the cover then renders the apparatus fit for further generation of gas. The small size cells shown in the reproduced photo., Fig. 1, have each an internal resistance of 0·2ω. They can, of course, be made of any desired internal resistance, and there is a large one at the works which gives 150 amperes on short circuit.

It is intended that the battery shall generally be used in conjunction with accumulators, so that advantage can be taken of the power the battery has of continuous working, allowing a much larger number of lamps to be run by charging the accumulators continuously day and night; while the E.M.F. at the terminals of the lamps is maintained constant with varying currents. A set of 11 accumulator cells is shown above the Upward battery in Fig. 1.

Some of the details of manufacture will show what great pains have been taken to make the battery a per-

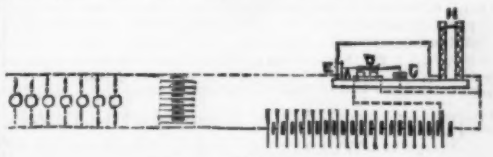


FIG. 6.—DIAGRAM.

fectly permanent thing, and fit for use in unskilled hands.

The whole of the outer cell being covered in with cement, the carbons are a fixture, and never require the least attention; the terminals on the carbons are brass clamps, and they have been found never to corrode or give the least trouble, there being no creeping of the liquid. The zinc connection is a copper strip riveted on to a lug cast on the top of the zinc plate, and the porous pot is thoroughly soaked in cement for an inch from the top, so that this part never gets damp or affects the cement seal. The tubes from cell to cell are perfectly insulated from the carbon inside; lead is

used for the tubes, and is found to be practically unaffected by the gas, a thin coating of lead chloride forming on the inside, which completely protects it. The gas is *drawn* into the cells, not *forced* in, so that there is a slight vacuum (2 or 3 inches of water) inside, which effectually prevents any possibility of leakage of chlorine, which might occur if there were pressure inside. The liquid used—$ZnCl_2$,—(the supply of which is kept up by the action of the cells) is deliquescent, so that there is no tendency of the crushed carbon to get dry.

The description and cuts will show that apparently the utmost simplicity has been attained, and that there is nothing in the battery at all likely to get out of order.

Its E.M.F. is 2·1 volts, and is absolutely constant so long as chlorine is supplied. The whole of the chemical changes being the combustion of zinc or iron by chlorine, and that purely electrolytically, there is an entire absence of local action. This has also been proved by delicate tests, and is clearly shown by the condition of the zinc plates shown us, which came out of the cells all on the same day, all used up to the thinness of a wafer, and every one to the same extent.

To the probable user of a primary battery, information on the amount of attendance required and the possibility of inconvenience is of the greatest interest.

Assuming the battery and apparatus to be installed in a cellar, outhouse, yard, or other convenient position, all that a servant has to do is, once a month, to fill the generator with a charge of manganese, and every few days to run sulphuric acid from one tap and brine from another into the funnel, after opening the lower tap to allow the spent liquid to run off into the drain, at the same time the burner underneath may be lighted; or, if preferred, the heat may be arranged so that the process is continuous. The necessity for fresh or more rapid generation of gas is indicated by the color bulbs

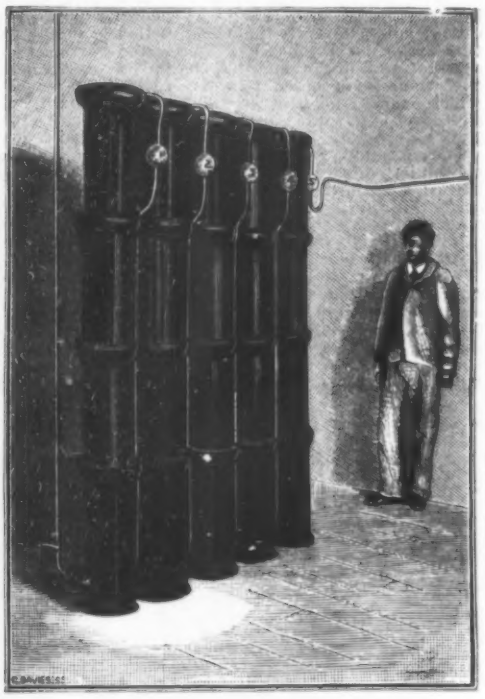


FIG. 7.

in the tubes between the holders, which show how many columns full of gas there are in hand.

The only other attention necessary is to fill up the cells with plain water once a week.

By using heavy zinc plates, the renewal of these is only necessary once in six months or more, and, as before stated, they are all consumed alike, so that the whole are ready to be replaced on the same day.

If a battery is going to be unemployed for a considerable time, all that is necessary is to turn off the taps, T, and raise the safety tube of the first bubbling bottle. The cells then draw in air instead of gas, and soon stop, leaving any gas in the holders for future use, while the liquid only percolates through the pots till it is level outside and in. To start the battery again, it is only necessary to open the taps, T, push the safety tube down again, and fill up with water, as plenty of zinc chloride solution has been retained in the inner cells.

With regard to the cost of the electrical energy produced by the battery, it is not to be considered that this will be so low as when obtained from an engine and dynamo; but in many cases these are perfectly inadmissible, and it is here that a reliable primary battery becomes invaluable. As to the actual working cost, for 1,000 watt-hours' work done we shall require, according to the inventor's calculations, $\frac{1,000}{2{\cdot}1}$ ampere-hours; or, since 1 lb. zinc is equivalent to 374 A.H., $\frac{1,000}{2{\cdot}1 \times 374} = 1{\cdot}27$ lb. at 2½d. per lb. = 3·2 pence, and 1·27 lb. of zinc to form $ZnCl_2$ consumes $1{\cdot}27 \times \frac{35 \times 2}{65} = 1{\cdot}36$ lb. Cl. We have no exact data of the cost of chlorine, but we believe it is generally reckoned, where used on a manufacturing scale, as costing £5 per ton. Of course, we cannot expect to get it at that rate on a small scale; but even assuming it costs six times as much, or 3¼d. per lb., we have the total cost per 1,000 W.H. as under 8d. Allowing for the battery working at a very high rate, and for loss in the accumulators, let us assume that as little as one-half of the total work is done on the lamps; then, taking lamps of the efficiency of 3 watts per candle, we have an outside cost per 1,000 C.P. hours of 8d. ×2 ×3, or 4s., or ½d. per hour per 10 C.P. lamp. Now, when burnt in an ordinary burner, 5 feet of gas do not give *more* than 10 C.P., so that, even taking the extreme figures for cost that we have done, we have electric light at a cost equivalent to gas at 8s. per 1,000 cubic feet.

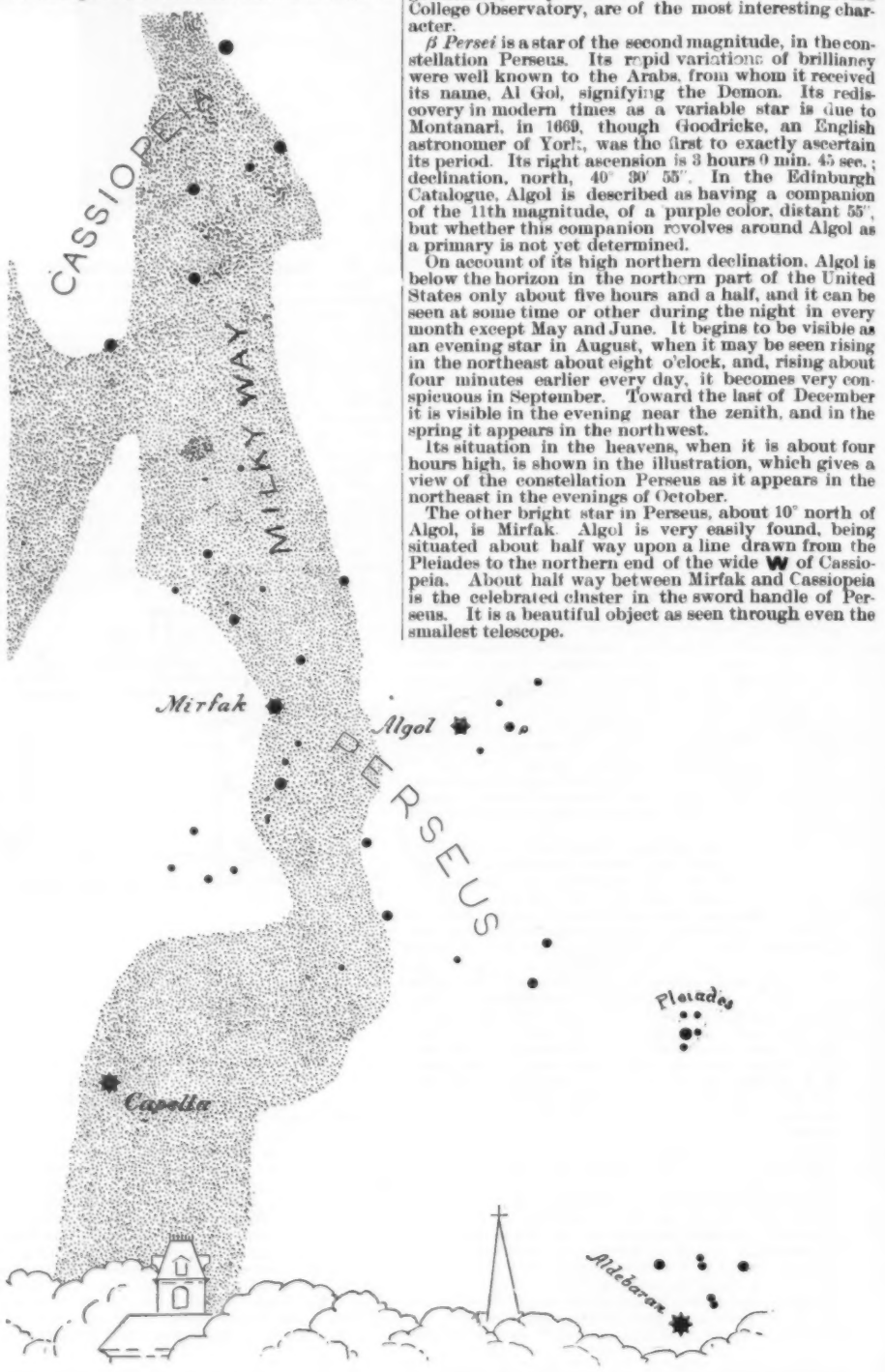
We have no hesitation in saying that if the battery gives as little trouble as asserted, there should be a very large field for its immediate introduction; and from the cells we saw and the report of Prof. Oliver Lodge, which, we learn, is particularly favorable, we have great hopes of its commercial success, believing it to be the first thoroughly practical primary battery for electric lighting.—*Electrical Review.*

THE ECLIPSE OF ALGOL, WITH THE LATEST DETERMINATIONS OF ITS DISTANCE AND DIMENSIONS.

By ROYAL HILL.

BY far the greater number of the stars visible to the naked eye appear to shine with unvarying brilliancy. But when we compare our own observations of their relative brightness with those of the astronomers of past ages, we find many stars in which very great changes have occurred in the amount of light emitted. Some are much brighter; others which were once among the brightest in their constellations are now quite inconspicuous. Even in our own day perceptible changes have occurred in the relative brilliancy of well-known stars. For instance, in the British Association Catalogue of 1850, of the two brightest stars of the constellation of the Twins, Castor is noted as being of the 1½ magnitude and Pollux of the 2d. At the present time the latter is evidently the brighter of the two.

Whether these variations are, in the majority of cases, of such a character that the stars will in time resume their former appearance, is not known, and it will be necessary to combine the observations of many ages of astronomers before this can be determined. There are, however, about one hundred and fifty stars whose variations of light are so decided in amount that they are known as variable stars, and the periods of maximum and minimum brilliancy of a large proportion of these have been ascertained with more or less exactness, dependent upon the length of their periods, which vary from a few days to several months or even years.



Variable stars are at present divided into five classes, according to the character of their changes. The most interesting of these is that in which the stars undergo for a few hours a remarkable diminution of light with great regularity of period—so regular, in fact, that astronomers who have investigated the subject have satisfied themselves and the majority of the profession, that the variation of light in stars of this class is caused by the revolution around a luminous sun of a dark planet of large size, the plane of whose orbit passes so near the earth as to bring the planet between us and the star at every revolution, and so cuts off a portion of its light.

Of stars of this class, only six are known, and of these, *β Persei*, otherwise known as Algol, is at once the most conspicuous and in many respects the most interesting of all the variable stars. Its variations have been the subject of investigation by many eminent astronomers, among whom are Herschel, Lalande, Argelander, Schmidt, Schonfeld, and, in our own country, Mr. Pickering. The researches of this gentleman, at present the Director of the Harvard College Observatory, are of the most interesting character.

β Persei is a star of the second magnitude, in the constellation Perseus. Its rapid variations of brilliancy were well known to the Arabs, from whom it received its name, Al Gol, signifying the Demon. Its rediscovery in modern times as a variable star is due to Montanari, in 1669, though Goodricke, an English astronomer of York, was the first to exactly ascertain its period. Its right ascension is 3 hours 0 min. 45 sec.; declination, north, 40° 30′ 55″. In the Edinburgh Catalogue, Algol is described as having a companion of the 11th magnitude, of a purple color, distant 55″, but whether this companion revolves around Algol as a primary is not yet determined.

On account of its high northern declination, Algol is below the horizon in the northern part of the United States only about five hours and a half, and it can be seen at some time or other during the night in every month except May and June. It begins to be visible as an evening star in August, when it may be seen rising in the northeast about eight o'clock, and, rising about four minutes earlier every day, it becomes very conspicuous in September. Toward the last of December it is visible in the evening near the zenith, and in the spring it appears in the northwest.

Its situation in the heavens, when it is about four hours high, is shown in the illustration, which gives a view of the constellation Perseus as it appears in the northeast in the evenings of October.

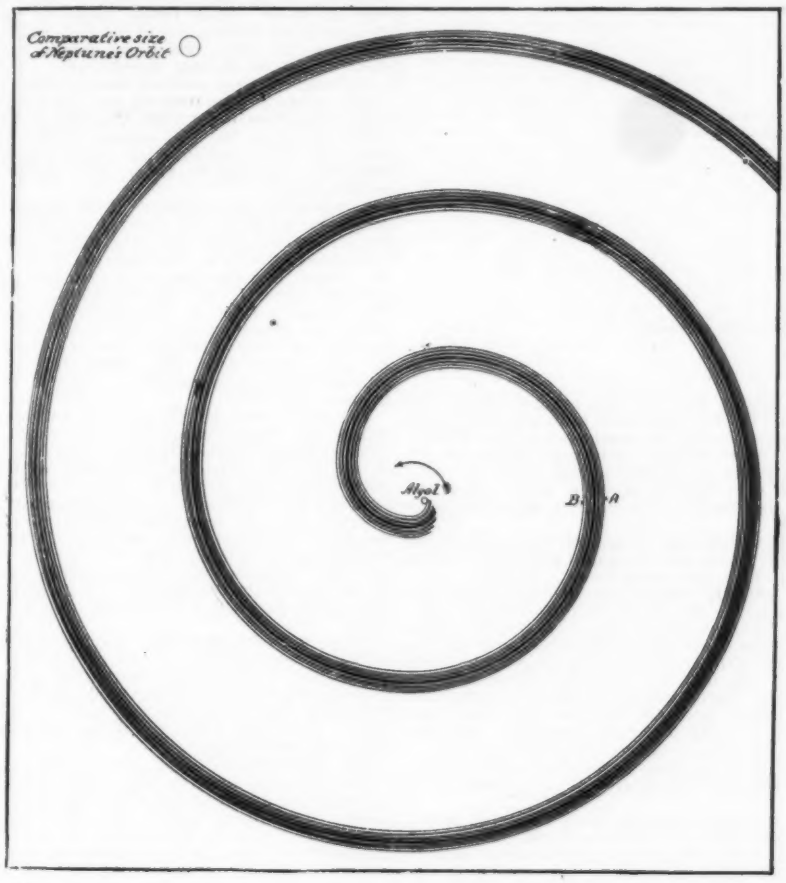
The other bright star in Perseus, about 10° north of Algol, is Mirfak. Algol is very easily found, being situated about half way upon a line drawn from the Pleiades to the northern end of the wide W of Cassiopeia. About half way between Mirfak and Cassiopeia is the celebrated cluster in the sword handle of Perseus. It is a beautiful object as seen through even the smallest telescope.

As usually seen, Algol appears as a clear white star of the second magnitude (more exactly 2·2), hardly so bright as Mirfak. It remains of this degree of brilliancy for about two days and twelve hours, when it begins to fade, and in four hours and a quarter it has lost so much of its light as to appear as only of the 4th magnitude. It remains in this condition for about fifteen minutes, and then begins to brighten, and in four hours more resumes its ordinary appearance. To the unassisted eye of the ordinary observer, there is no very perceptible diminution of the light except during the three hours on each side of the minimum. During the time that the light is the least, it can be compared with the fourth magnitude star ρ, a little to the south of it (marked in the illustration); it will be then seen to be a very little brighter than ρ.

Various conjectures have been made as to the cause of this phenomenon, but the exact equality of the intervals between the minima has disposed of all theories except those based upon the rotation of the star itself, or the revolution around it of some dark body which intercepts part of its light.

For a long time the first of these suppositions was the only one entertained, one side of the star being considered as not being so bright as the other, and by

its periodical presentation to the earth to cause the observed diminution of the light. But when astronomers began to measure the amount of light received from the star, and found that it came without any perceptible diminution for two days and a half, it was seen that this theory was inadequate to account for the appearances. It is evident that, if one side of the star is not so bright as the other, there would be a gradual decrease of light during one half the period of its rotation, and an equally gradual increase during the other half, the decrease and increase occupying the whole period, which is contrary to what is observed. No theory is admissible which does not leave the light of the star undimmed for nearly seven-eighths of the whole period. To obviate this difficulty, Algol was supposed to have a large spot near one of its poles, and to be so poised as regards the earth that the spot is visible during only a small part of its period of rotation. But as the light of the star at minimum is less than half its normal brilliancy, it has been found impossible to locate so large a spot as is necessary to produce this diminution so that it should not present itself for sixty hours out of sixty-nine. There are also dynamical objections to this theory which cannot be disposed of. According to this supposition, Algol makes one revolution on its axis in about sixty-nine hours, which is scarcely one-ninth of the rotation period of the sun. Such a speed is incompatible with its existence as a spherical body, unless it is very much smaller than the sun. As it is certain, from considerations yet to be presented, that Algol is very much larger than the sun, the theory becomes inadmissible, and, in fine, the difficulties connected with it are so insuperable that astronomers have ceased to consider it as a possible explanation of the periodical diminution of the light of the star.



There remains, then, the theory of a body, usually spoken of as a dark planet, revolving around Algol, and passing at every revolution between it and the earth, and so cutting off a portion of its light. During the rest of the period, the planet would be to the side of or behind the star, whose light, therefore, would come to us undiminished.

The objections made to this theory are, that there is no instance in the solar system of any planet so near the same size as its primary as the supposed planet must be to intercept so large a portion of the star's light, nor any so near as to be forced to revolve in so short a period as that observed. Neither is it conceivable, say the opponents of this theory, how such a body can be dark; being so near the same size as its primary, it should itself be luminous, and, even if not quite so intrinsically bright, because, being of smaller size, it has cooled off more, yet it would be incapable of producing any marked diminution of the light coming from the star. To these objections the reply is made that the absence of such a secondary in such close proximity to the sun in the solar system is no proof that such may not exist in some of the stellar systems that surround us on every side. It is not at all necessary that such a planet should have the same origin as the star, that is, have originated from the same nebulous mass from which Algol has contracted. It may be, and probably is, a dead sun that has been brought within the attractive influence of Algol, under such conditions as to be forced to travel in a closed and very small orbit around it. On the other hand, it is shown that the observed phenomena are completely explained by the existence of such a dark satellite, while no other theory hitherto advanced will explain them. The most careful observations of astronomers armed with the most refined instruments of modern optical science, and these combined with the strictest mathematical analysis, only tend to confirm this theory, and have at length resulted in giving us as precise conceptions of the conditions of Algol's system as we have of any in which both bodies are luminous and therefore visible.

—Fig. 1—

Upon this theory Algol suffers a partial eclipse of about nine hours duration once in each revolution of a planet having a period of two days and about twenty-one hours. Careful photometric observations have resulted in establishing the ratio of the light of the star when at a minimum to that at maximum as 416 to 1,000. There are several ways in which a dark body of sufficient size might be interposed so as to reduce the light in this proportion. If we suppose the eclipse is caused by the interposition of a body as large or larger than the star, so placed as to cut off 0·584 of its surface from our view, then, if we had no further data, we might suppose the planet to be of any size if it only traveled fast enough to begin and end its transit within the observed time of its continuance. This may be considered as one extreme of the possibilities, and it will be seen by examination of Fig. 1, which represents the eclipse of the star by a dark body of twice its diameter, that in such a case the light would decrease from the beginning of the transit to the middle, and then immediately begin to increase. It is also evident that this decrease and increase at the middle would be more or less rapid according to the relative degree of curvature of the circumference of the planet as compared with that of the star—the larger the body, the more rapid would be the change at the beginning and end of the eclipse, and the slower it would be at the middle.

—Fig. 2—

If we suppose the eclipse to be caused by the transit across the center of the star of a planet just large enough to cover 0·584 of its surface, we have the other extreme represented by Fig. 2.

Here, it is evident, we have an annular eclipse, and that during the time the planet is traveling across the face of the star, that is from the time that the annular phase begins (as represented in the figure) till it ends, the light would remain at a minimum. It will also be seen that the decrease and increase would be more rapid just before and after the annular phase than at the beginning and end of the eclipse.

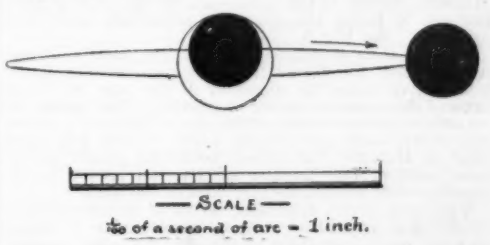
If, therefore, we can ascertain the exact proportion of the whole light of the star which is cut off at regular intervals during the eclipse, we have the proportion of its surface which is covered from view at the time, and the relative diameters of the star and planet can be computed. Some of the most eminent astronomers of the present day have applied themselves to this task, notably Argelander, Schonfeld, and Mr. Pickering. The result of their researches is shown in the following table, which exhibits the amount of light received from the star at intervals of half an hour each way from the middle of the eclipse:

From Minimum.	Light.	From Minimum.	Light.
At 4·6 hours.	1000	At 2 hours.	685
" 4 "	968	" 1½ "	566
" 3½ "	920	" 1 hour.	480
" 3 "	861	" ½ "	433
" 2½ "	762	Minimum.	416

From these data it was required to compute the diameter of a planet which, during its transit in the time observed, should cover the surface of the star in correspondence with the above diminution of its light. In general terms, the result of the investigations is that a planet having a diameter 0·764 that of the star, and occupying nine hours and twelve minutes in its transit, will intercept just that amount of light which is missing at the observed intervals, if the plane of its orbit is so placed in respect to the earth as to produce an eclipse nearly, but not quite, annular.

As soon as the relative sizes of the two bodies had been ascertained, it became possible to compute the relative size of the orbit in which the planet revolves. Knowing the whole period and the time occupied in transit, and combining these with the ratio of the diameters, it was found that the diameter of the orbit of the planet is 4⅘ times that of the star, or 6·1 times that of the planet.

Fig 3 gives a view of the relative sizes of the star,

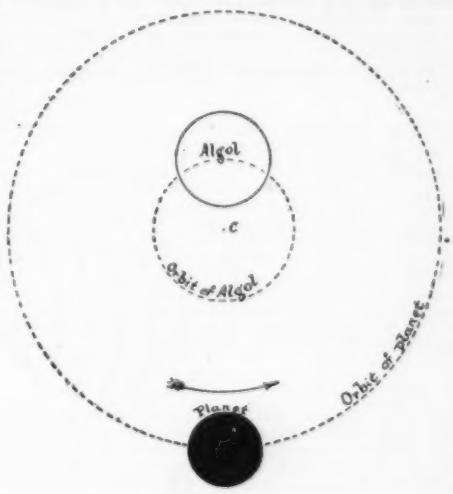


—Fig. 3—

the planet, and its orbit, the planet being shown at the middle of the eclipse and also at one elongation, the orbit being presented as seen from the earth.

Fig. 4 represents the orbit in its own plane. It will be observed in this view that the star has an orbit around the common center of gravity at C of the two bodies of about one-third the diameter of the orbit of the planet. This is according to the ratio of the masses of the two bodies, which, supposing them to be of the same density, is as 1·0 to 0·446.

So far the *relative* dimensions of Algol and its dark secondary. The absolute dimensions cannot be determined with the like accuracy. The following considerations, however, are extremely interesting, and afford an approximation to the desired information.



—Fig. 4—

From the distance at which we are from the sun, he presents to us a disk of 32′ 4″ in diameter, or 1924″. In order to present to us the appearance of a star of the same magnitude as Algol, he would have to be removed from us about 320,000 times as far as he is now, and his disk would then be six one-thousandths of a second (0″·006) in diameter, becoming, in fact, as every fixed star is, a mere point of light. The sun's annual parallax at this distance would be six-tenths of a second (0″·6). This is a larger parallax than any fixed star has, except perhaps *α Centauri*.

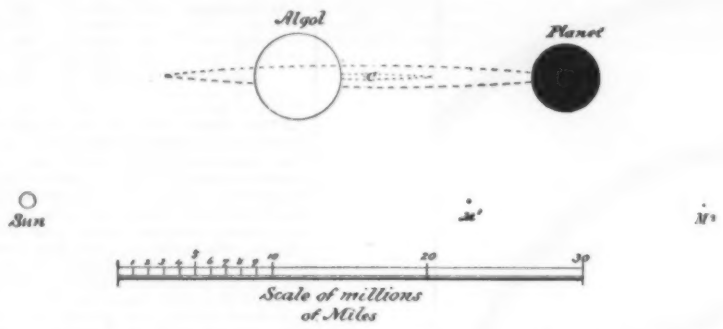
But the parallax of Algol has not been determined, being so small as to escape the fine nets which astronomers spread for such exceedingly minute quantities as stellar parallax. The parallax of Algol is certainly not more, if so much, as one-tenth of a second (0″.1); for if it

were as large as this, it could not have escaped observation and approximate measurement. If the sun were removed from us to such a distance that its parallax were 0".1, it would then be only a sixth magnitude star, and scarcely visible to the naked eye.

This shows that Algol must be very much larger than the sun, probably not less than six times larger in diameter, it being a second magnitude star at a distance from which the sun would appear to be only of the sixth Even if this difference of magnitude is partly due to a superior brightness of its surface, we have a reserve of smaller parallax for Algol than 0".1 to fall back upon. It will, however, simplify these considerations to suppose Algol as being of the same intrinsic brilliancy as the sun, and to have an annual parallax of one-tenth of a second (0".1). Its apparent disk being six one-thousandths of a second (0".006) in diameter, its actual diameter would be 5,544,000 miles, that of the planet being 4,235,000 miles and of the orbit 25,895,000.

We thus become able to apply a scale of miles, instead of one of arc, to Figs 3 and 4, one view being here reproduced, with the sun and its nearest planet, Mercury, drawn to the same scale for the sake of comparison M^1 being the planet at perihelion and M^2 at aphelion. See Fig. 5.

—Fig. 5—



Algol is thus shown to be a sun very nearly six and a half times the diameter of our own, with a planet nearly five times the diameter of the sun revolving around the common center of gravity of the system, in an orbit about one-third of the size of Mercury's, at the rate of 327 miles per second, which is over ten times that of Mercury, the fastest traveling planet in the solar system, the motion of the star itself in its smaller orbit being one-third that of the planet.

Vast, and indeed appalling, as these dimensions and speeds may appear to us, because we are accustomed to limit our conceptions to those of the solar system, yet we have no right on that account to reject the conclusions arrived at. It is very certain that the annual parallax of Algol is less than 0".1; and to be of the observed magnitude, the star must be thus immensely larger than the sun, if of the same intrinsic brightness.

It is interesting to note, and gives an idea of the immense distance of the fixed stars, that if Fig. 3 were placed 325 miles from the eye, if would be of the same angular dimensions that are presented by Algol and its dark secondary, that being the radius of a circle in which 0".006 would be equal to the diameter of the little circle representing Algol in the figure. Of course, the actual distance of the star exceeds 325 miles in the same ratio that its actual size exceeds that of its little representative, that is, as 5,544,000 miles is to 0.6 of an inch. This distance will be the same as the radius of a circle in which 0".006 shall be equal to the diameter of the star. Either way gives a distance of 190,576,000,000,000 miles, which also corresponds to that due to an annual parallax of 0".1, the distance of the earth from the sun being considered as 92,394,000 miles, computed from Professor Newcomb's solar parallax of 8".848. This distance of Algol is a little more than that given by Peters as the average distance of second magnitude stars, and is what we should look for, as Algol is less than the second magnitude. Like all estimates of the distances of the fixed stars, it is but an approximation.

To cross this enormous distance, light, traveling at the rate of 186,000 miles per second, requires nearly thirty-two and a half years, and over it are spread over four thousand pulsations of the light of the star. It is somewhat novel to conceive of this partial shadow of Algol's satellite as traveling out from the star in a perpetual spiral generated by the revolution of the planet combined with the velocity of light proceeding in straight lines. The accompanying illustration gives a view of this spiral as it must actually exist, and as it would be seen by an eye capable of seeing the transmission of light when situated at a sufficient distance above the plane of the orbit of the planet.

The small circle in the center may be supposed to be the planet's orbit, though vastly too large for the scale of the drawing. The planet traveling in the direction of the arrow leaves the shadow behind it, which darts out from the star at the rate of 186,000 miles per second, and by the time the planet has returned to its position, the shadow of the previous eclipse is 46,078,000,000 miles on its way. For about nine hours a partial eclipse ensues, the shadow being deeper in the middle than at the beginning and end, during which time the beginning of the eclipse has advanced 6,010,0 0,000 miles. This last, which is the width of the shadow, is somewhat over the diameter of the orbit of Neptune, which, for the sake of comparison, is drawn to the same scale in the upper corner. The light space some 40,000 millions of miles in width is that occupied by light in traveling the sixty hours during which the star appears of its full brilliancy. By rotating the page in the direction of the arrow, which is the same as that of the planets round the sun, the spiral path will seem to advance outward. The motion would be exactly imitated, and, in fact, be produced, on the same principle, by causing the point of a stick to mark a circular path in the center of a smooth sheet of water, when the wave would be found to travel in a spiral direction to the shores.

How far that shore may be against which the waves of Algol's light break, and the spiral path of its eclipse is extinguished, we may never know. It reaches us in about thirty years, by which time Algol has diminished from a tremendous sun to a star of the second magnitude. After traveling one hundred and twenty years, Algol sinks to the eye of the distant observer to the 6th magnitude, and if that eye is like ours, it cannot be seen at minimum. The light of a star of the 15th magnitude is estimated to have been on its journey nearly 2,000 years, and smaller and still more distant stars than these are now seen with the largest telescopes. But how far the light of such a star as Algol must travel ere it would be unable to produce vibrations visible to any eye, or else meet the ramparts of space, cannot be known.

It may be said that any dark body revolving round a luminous sun produces such a spiral path in its shadow. But it is only in such instances as that of Algol, in which a sun has a planet very near to it, and therefore revolving at a very rapid rate, and of sufficient size to intercept a large proportion of the light emitted, that the distinction of full light and the eclipse, and also the angle of the spiral, would be sufficient to make such an illustration interesting. Jupiter, for instance, being about one-tenth the diameter of the sun, only intercepts to the eye of the distant observer one-hundredth of its light, and this only for a few hours in a period of about twelve years.

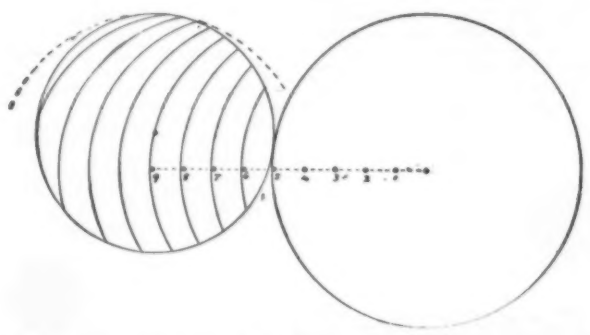
So far the period of Algol has been spoken of as about sixty-nine hours. A nearer approximation is about eleven minutes less than this. In 1784 Goodricke ascertained its period to be 2 days 20 hours 48 minutes 58·6 seconds. Since then it has been gradually decreasing, and is now 2 days 20 hours 48 minutes 52·5 seconds. To account for this decrease, it is conjectured that the planet moves in a resisting medium the effect of which would certainly be to cause the planet to draw nearer to the star. It is not at all unlikely that the immediate neighborhood of all suns is occupied by vast clouds of meteors, which would resist slightly the passage of a large body among them. But such can hardly exist near Algol, as the disturbing effect of such a large body as the planet must be enormous, and would eventually precipitate every small body upon the surface of either the star or the planet. It may be that this constant increase of the mass of the two bodies may be the cause of the decrease of the period. If there is any resisting medium, it is more likely to be the tremendously extended atmosphere of the central body, in which case the planet itself must eventually be brought to the surface of the star.

A singular circumstance in connection with this decrease of period is that nearly one-half of the decrease since 1784 occurred during the ten years between 1840 and 1850. This may have been occasioned by a sudden increase of the mass of one of the two bodies by the falling into it of some extraneous body not sufficiently large to produce any marked increase of the light.

Another theory has been brought forward to account for the variation of Algol. It is that a vast cloud of meteors, and not a massive planet, revolves round the star in the observed period. It is easy to conceive that such a cloud exists and should cut off just so much of the star's light. But it is not easy to conceive how such a cloud should be of such an exact circular form as to fulfill the conditions of the eclipse as the planet does, and, still more, how it should preserve this form, being neither condensed by the mutual attraction of its members to the center of the mass and so shorten the duration of the eclipse, nor be scattered by the perturbations of other masses in the system, and so lengthen it. Such changes have occurred, and are yet occurring, in the meteor systems of the solar system, such as those which follow cometary paths. The changes in the dimensions of Saturn's ring are strictly analogous to those which we might look for in a cloud of meteors circling round a star. If it shall be found that the light received from the star during the eclipse varies as time rolls on, and the duration of the eclipse lengthens or shortens, then the meteoric theory will be taken as the explanation of the phenomena. But as no such variation has been observed, we are compelled to accept the theory of a stable body such as the planet.

A very neat demonstration of the conditions of the eclipse can be made by drawing on good cardboard two circles tangent to each other of 10 inches and 7 64 inches respectively, as representing the beginning of the eclipse, and drawing the larger circle again in the position shown in Fig. 3 for the middle of the eclipse. The distance between the centers of the two large circles can thus be divided into nine parts, representing the half hour intervals of the table on page 8915. By arcs drawn from the points thus obtained, the smaller circle can be traversed as shown in this illustration. Fig. 6.

Fig. 6



The two circles should then be cut out, and the smaller one divided up on the lines. The larger circle should then be weighed in grains, and from this weight should then be subtracted the weights of the successive portions of the smaller circle. If these remainders, which strictly represent the area of the star uncovered at each interval, are put in decimal proportion to the whole weight of the larger circle, they will be found to correspond pretty closely with the light of the star in the table. A more exact demonstration can be made by correcting the distances 1, 2, 3, 4, representing the half-hourly progress of the planet, for the curve of the orbit.

When we remember that the amount of light at each half hour interval of the eclipse was accurately ascertained by years of observation before any attempt was made to compute the size of the planet, it is difficult to believe that we have not here the true solution of one of the most interesting problems ever presented to astronomers.

The variations of Algol are, of course, most conveniently observed in the evening. The minima of light occur at intervals of about three days, each one being nearly three hours earlier than the preceding. In this way they run the course of the twenty-four hours in about three weeks. When a minimum occurs at a convenient hour of observation in the evening, seven periods of the eclipse will bring another minimum twenty days after, but one hour and forty two minutes *later*. If this is inconveniently late, another period will bring one twenty three days after, but one hour and twenty-nine minutes *earlier*.

The length of the interval is such that fifteen periods make forty-three days and thirteen minutes. Consequently, minima are repeated at the same hour of the day at intervals of six weeks and one day.

The most interesting phase to observe is the decrease of the light from the normal brilliancy to the minimum as the phenomenon is a little more striking, and partly because the decrease, owing to a slight ellipticity of the orbit, is rather more rapid than the increase.

The following is a list of the dates in the latter part of 1886 and the first two months of 1887, on the evenings of which the minimum of Algol's light may be observed. The dates are given in Eastern standard time. For central time they will be one hour earlier, and for mountain time two hours earlier.

September	28	10.41 P. M.
October	1	7.30 "
"	19	12.23 A. M.
"	21	9.12 P. M.
"	24	6.04 "
November	10	10.54 "
"	13	7.43 "
December	1	1.36 A. M.
"	3	9.25 P. M.
"	6	6.14 "
"	23	11.07 "
"	26	7.56 "
January	13	12.49 A. M.
"	15	9.38 P. M.
"	18	6.27 "
February	4	11.20 "
"	7	8.09 "
"	27	9.52 "

The season of the year when evening observation of Algol may be commenced is about the 1st of September, when the star rises about 7 o'clock. The following are the dates nearest September 1 for the next three years, when the minimum may be observed in the evening:

Sept.	10, 1887	9.16 P. M.
"	11, 1888	9.33 "
August	24, 1889	8.08 "

THE NEXT LOUISVILLE EXPOSITION.

FOR three years past, commencing with 1883, the exhibitions held at Louisville, Ky., have been brilliantly successful, alike in the attendance and in the variety and excellence of their display of works of art, industry, and agriculture. This year the exhibition opened August 28 and closes October 23, and its managers propose to make the show contribute materially to the attractions which Louisville always presents to visitors at that season.

NIAGARA RIVER, GORGE AND FALLS.

By H. C. HOVEY.

ACCORDING to previous announcement, the geological section of the American Association for the Advancement of Science, during the Buffalo meeting, August, 1886, gave especial attention to the various features of Niagara. Papers were read as follows: On the Niagara Gorge, by Dr. J. Pohlman; on the Rate of Recession of the Niagara Falls, by Prof. R. S. Woodward; on Buffalo and Chicago, or what might have been by Prof. E. W. Claypole; on the Place of Niagara Falls in Geologic History, by Prof. G. K. Gilbert; and on New Facts bearing on the date of the close of the last Glacial Period, by Prof G. F. Wright. In the discussion of these valuable papers, Prof. James Hall, Prof. Chamberlain, and other noted geologists took part. There were also excursions, one to Grand Island, another down the Niagara to Lewiston, and across to St Davis, requiring some hard field work. Without attempting a full report of all that was said and done, I shall mention what seemed of most interest at the time.

It should be noted at the outset that the great State of New York, with its five millions of people and boundless wealth, has had no survey of Niagara made for the last twenty years. Then the popular notion should be commented on that this cataract may be regarded as a sort of yardstick by which to measure off geological time. The precision with which this can actually be done, and the sort of calculation the task requires, was well set forth by one of the geologists in the follow equation:

Time = length of gorge ÷ by rate of recession
− effect of thinner limestone.
− " " thicker shales.
− " " narrower cross-section.
− " " more floating ice.
− " " antecedent channels.
± " " changes in volume of water.
± " " " base level.
± " " " detrital load.
± " " " chemical action.

Working out this formula as well as he could from ascertainable data, his conclusion was that the time required as a maximum period was 7,000 years, the minimum being about 3,000 years.

Prof. Woodward finds that, from 1842 to 1875, the Horseshoe Fall has worn away 4·25 acres and has receded 2·44 feet per annum. From 1875 to 1886 the wearing amounts to 1·37 acres and the recession 2·38 feet a year. From this it appears that it may take 1,100 years for the falls to recede one mile. The American Falls, being probably over harder strata and with less volume, do not recede so rapidly. It is evidently erroneous to judge of the past rate of recession by the known present rate. From the escarpment at Lewiston to the bend above what is known as the Devil's Hole, a distance of four and a half miles, the soft shales (a sort of indurated clay) vary in thickness above water level of from 110 to 130 feet. The so-called Niagara limestone, which, in the gorge, is about ten feet thick, increases in thickness till, at the Falls, it is fully 80 feet thick. These facts, and others to be mentioned presently, justify the conclusion that in former years the retrocession was at a far more rapid rate than now.

It was shown by Prof. Gilbert that, at the close of the glacial period, when the ice retreated so as to change the outlet of Lake Ontario from the valley of the Mohawk to that of the St. Lawrence, the water, which had previously been much higher, fell away to about its present level. Prof. W. M. Davis pointed out the fact that the rocks above the whirlpool present a much more modern appearance than those at the whirlpool, which latter were probably cut by a pre-glacial stream.

If there were ever any falls at Lewiston which is now doubted by many, they could not have been very great till after the subsidence of Lake Ontario. Prof. Comstock, of Cornell University, said that he was struck by the two marked trends of the river below the Falls, and held that a stream would always follow a line of joints in a seam as long as possible. And when stopped in its original course, it would often turn at right angles from its channel. He also held that there was never any fall at Lewiston, the rocks being too thin and friable to afford enough resistance to allow the formation of anything more than the rapids of a swift river.

The origin of the Niagara River, according to the able and ingenious paper read by Dr. Pohlman, of Buffalo, carries us back to pre-glacial times. Evidence of this is to be sought for, as he said, in a comparatively limited area distinctly circumscribed. This region was bounded on the north by the valley of Lake Ontario, on the east by the Genesee Valley, on the west by the Dundas Valley, and on the south by a line between the watersheds of the Genesee and the Dundas. The northern portion of this area is occupied by the Niagara limestone; the middle by the soft shales and gypsum beds of the Onondaga salt group; and the southern by the magnesian and corniferous limestones, their highest crest being about fifty feet higher than the highest line of the Niagara limestone, with an average dip of 20 feet to the mile from north to south. Erosion must have been more rapid on the soft rocks than on the hard rocks, thus forming a depression in which the drainage would flow. Its northern boundary would be the crest of Niagara limestone running between two and four miles south of the Lewiston escarpment. The waters, by fluctuation of level, removed the soft rocks, thus undermining the harder strata and producing a steep cliff, known as the second terrace of Western New York. We may call this body of water the Tonawanda. Owing to the fact that its northern barrier was lower than the southern, the overflow would be toward the Ontario Valley; and we find this plainly marked from the thin strata near the present falls down to the whirlpool, and thence through the drift-filled valley of St. Davis toward the ancient Ontario. Prof. Hall gave this valley a pre-glacial origin; and from the observations now made we may imagine its appearance just prior to the ice period. From Lake Ontario we should follow up the rapids flowing over the Medina shales, through the valley of the St. Davis, to the sandstone band near the whirlpool, and ascend the present river gorge to the second fall of the river over Clinton limestone, a little south of the railway suspension bridge. Continuing in the same direction, over the Niagara shales, we would reach the upper fall over the more solid limestone, about three-fourths of a mile north of the new suspension bridge. Thence other rapids would lead us over thin strata of limestone, ending our ascent near the first line of breakers of the present rapids above the falls. Grand Island was a kind of peninsula formed by the meandering course of the river. The ancient Tonawanda River began about where the Niagara does, ran around the southern margin of Grand Island, and thence northward across the breakers. The branch north of the island is of quite modern origin.

The original point of overflow was south of the upper rapids, and thus the waters predetermined the gorge between the falls and the whirlpool, and thence flowed northward through the valley of St. Davis till they descended over the escarpment, and thus the three falls were formed, namely, those over the Medina sandstone, the Clinton limestone, and the Niagara limestone. The rocks in certain places were naturally cut more deeply than elsewhere, owing to differences of hardness, and thus the islands were formed, known now as Goat, Bath, Lima, etc. The smaller body of water flowed east of Goat Island and the larger on the west, for similar reasons the larger, deeper channels being formed where there was least resistance. These currents drew together as one body as they approached the heavy, homogeneous Niagara limestone and rushed down the first fall for perhaps 100 ft. The second leap was over the Clinton limestone, near the railway suspension bridge. Thence a short rapid carried it to the entrance to the whirlpool, where another fall was caused by the quartzose sandstone of the Medina group, and this excavated the bed of the ancient river below the line of the present one, as is shown by the drift filled hollow facing the whirlpool. From here a rapid current carried the Tonawanda through the St. Davis Valley to the Ontario.

The volume of water was small as compared with the present estimate of 20,000,000 cubic feet a minute of Niagara River; but the factor time favored the Tonawanda.

The motion of the ice sheet in the glacial period, as show by striæ and grooves, was N. N. E. and S. S. W., and slowly overflowed the Lewiston heights, filled the valley of the Ontario, and entered the valley of the Tonawanda. A lake was on its advancing margin, whenever the ground made it possible; and thus the waters that had been drained through the valley had to find another outlet. Next the retreat of the ice sheet, owing to climatic changes, spread the drift over the land it had occupied, and more or less filled up the valleys. Lake Erie and Lake Ontario were then formed, the former of which was stationary, while the latter slowly subsided. The lakes were drained together across the intervening mud flat, and not by *falls* at Lewiston, as hitherto taught; the relation for the time being like that now existing between lakes Erie and Huron. This is demonstrated by the terraces, which show the lakes to have been connected by a swift river, but *without any falls*, simply deepening its bed in the drift and shaping its course along the buried pre-glacial valleys. But when the waters had cut through to the limestone, the current began to be broken by rapids. The gorge between Lewiston and the whirlpool was rapidly excavated. The little pre-glacial stream had prepared the way for the tremendous flood and determined its course. There was constant and rapid erosion on all sides, as the drift was removed. It is popularly accepted that the Niagara River cut its own gorge from Lewiston to the present falls; but we see this to be an error. The rocks to be thus excavated did extend to the whirlpool, but when the Niagara reached this point it found the ancient valley of the Tonawanda, which it followed, turning almost at right angles to do so.

All that the immense rush of water has been since able to do toward excavating anew its ancient (now drift-filled) outlet by way of the St. Davis Valley is to cut out about one thousand feet—the portion now known as the whirlpool. Above this the falls of the pre-glacial river again came into action, one after another, the lower ones gradually changing into rapids, while the retrocession of the upper one would become slower and slower, by reason of the increasing thickness of the Niagara limestone. The remnants of the lower falls, traveling back through the softer strata, finally joined the upper to form one grand cataract, divided by Goat Island into the American and Canadian Falls, both following the outlines originally marked out by the pre-glacial Tonawanda.

Let me briefly recapitulate in Dr. Pohlman's words: "In the pre-glacial time, a stream filled the valley of the Tonawanda, whose surplus waters formed an outlet along the gorge of the present Niagara River, from the falls to the whirlpool, and thence by way of the now drift filled valley of the St. Davis into the Ontario. After this valley had been closed during the ice period, Lakes Erie and Ontario subsided together until separated by the Lewiston escarpment; then the drainage of the first found its way through the drift deposits along the ancient river valleys between Buffalo and Lewiston. Owing to the slow subsidence of Lake Ontario, there never was a fall of any kind at Lewiston, but the river excavated its gorge thence to the whirlpool along an old shallow valley, as a rapid. Here it met the pre-glacial Tonawanda, along which the fall of Niagara receded to its present site."

I have thus tried to do ample justice to Dr. Pohlman's views on account of their originality, the very great interest they awakened in the geological section, and, let me add, because they seem to be sustained by the facts in the case. This was the conclusion, at least, of those who, after hearing his paper, tramped with painstaking care over much of the region described, and, especially that about the whirlpool and St. Davis Valley. It should be stated, however, that some of the more conservative geologists, among whom may be named Prof. James Hall, adhere to the older theories.

BUFFALO AND CHICAGO.

Prof. E. W. Claypole, of Akron, O., read an entertaining paper concerning what might have taken place under very slight changes of conditions. Buffalo is now the outlet port of the great lakes, and Chicago the port at the head of navigation; a relationship not accidental, but based on geological causes existing before those cities were built. Everything depended on the drainage of the lakes. A large part of the fresh water of the globe is banked up on a tableland 500 ft. or 600 ft. above the level of the sea, combining as the four great upper lakes. The drainage, of course, flows over the lowest point, which is at Black Rock, near Buffalo. But the watershed behind Chicago is only 12 ft. above Lake Michigan and 35 ft. above Lake Erie. Consequently, a dam 35 ft. high at Black Rock would suffice to throw the waters of the upper lakes into the Mississippi by way of the Illinois River. In that case the St. Lawrence would be reduced to an insignificant stream, and the dirty ditch known as the Chicago River would carry the tribute of the great lakes to the Father of Waters. Then, again, there is the retaining dam at Queenstown Heights, which now rises 40 ft. above Lake Erie. Why did Niagara River take its course over this barrier, instead of the Illinois flowing out over the ridge at Chicago 15 ft. lower?

There are two possible solutions of this problem. First, in the ice period the northwestern portion of the continent was depressed much below its present level, in places to the extent of hundreds of feet, and rose again as the ice disappeared. The flow of Niagara is known to have begun before that melting of the ice-sheet, and the river may therefore have found the ridge at Queenstown sufficiently *low* to allow of its passage, and sufficiently *slow* in its subsequent elevation to permit the maintenance of the channel. A change in these conditions might have forced the water to seek an outlet at Chicago. Secondly, owing to the slow northward retreat of the edge of the glacier, the channel at Mackinaw was ice-locked long after that at Black Rock was open. The waters of Huron and Erie were therefore cut off from the Michigan basin. Unable to escape by way of Chicago, they must have risen till they found an outlet over the Silurian escarpment at Queenstown, even supposing it to be at its present level.

Possibly both these causes were at work in determining the course of the Niagara. But it is interesting to note that, had the rim of the basin at Black Rock been originally a few feet higher, had the ridge at Queenstown risen more rapidly after its glacial depression, or had the channel at Mackinaw been unlocked before the outlet from Lake Ontario was free from ice, then Niagara would never have existed, but a broad stream would have borne the waters of the four lakes past Chicago along the valley of Des Plaines River into the Illinois and the Mississippi. Possibly the difference to the world might have been slight, but Chicago would have had the great river.

THE IRRIGATING CANALS OF NORTHERN COLORADO.

THE following data in regard to the principal irrigating canals of Northern Colorado are from the annual report of the Denver Chamber of Commerce, by Mr. James Duff, of Denver. The basis of calculation as to the number of acres each is capable of irrigating is that a cubic foot of water per second will irrigate fifty acres of land. It may be well to state, in this connection, that the estimate of the State Engineer, Mr. E. S. Nettleton, is that the duty of a cubic foot per second is fifty-three acres. This officer is also of the opinion that, by the employment of the perfected economic methods for the distribution of water in use in those counties where the system has been longer in use, the duty, otherwise capacity, of the present canals can be doubled and possibly trebled, but this is a problem to be solved hereafter.

LARIMER AND WELD CANAL

takes its supply from the Cache la Poudre river in Larimer county, near the prosperous town of Fort Collins, at the crossing of the Colorado Central and the Greeley, Salt Lake, and Pacific railroads. The canal extends from the mountains, and crosses the Denver Pacific railroad at a point about three miles north of the town of Eaton. It empties its waters into lakes Lee, Roscobie, and Forfar. The total length is forty-five miles, width thirty feet, depth five feet, grade per mile 2·34, capacity 720 cubic feet per second, will irrigate 36,000 acres, of which there are now under cultivation 25,000 acres.

THE LOVELAND AND GREELEY IRRIGATION AND LAND COMPANY.

This canal takes its water from the Big Thompson river, two miles west of the town of Loveland, in Larimer county. It passes through the town of Loveland, a thriving place on the Colorado Central railroad, and extends eastward to the well known town of Greeley, founded twelve years ago by the Greeley colony, and located on the Denver Pacific railroad. The length of the canal is thirty-one miles; width twenty-six feet; depth five feet; grade two and a half feet per mile; capacity 446 cubic feet of water per second; will irrigate 22,300 acres, of which there are now 10,000 acres under cultivation.

THE PLATTE VALLEY CANAL

takes its water from the Platte river, in Weld county, at a point between the villages of Fort Lupton and Platteville, two stations on the Denver Pacific railroad. It extends northward for a distance of ten miles in close proximity to the railroad just mentioned, thence eastward and southward about eighteen miles, making a total length of twenty-eight miles completed. It will be extended, probably within a year, a distance of ten to fifteen miles further, to a point where it will empty into the Box Elder creek. A dam across the Platte river, at the head of this canal, has recently been constructed at a cost of $5,000. Width of canal is twenty-six feet; depth three feet; grade per mile seven feet; capacity 494 cubic feet per second; will irrigate 20,200 acres.

THE PLATTE CANAL (ALIAS THE HIGH LINE CANAL).

This canal was constructed by the Northern Colorado Irrigation Company, at a cost of nearly three-quarters of a million dollars. Its initial point is in the canon of the South Platte river, in Jefferson county, about twenty miles from the city of Denver. A tunnel of 700 feet in length, twenty feet wide, and ten feet high, cut entirely through the hardest granite, also a bench cut out of the rock a distance of half a mile, on which to build a flume, had to be made in order to get the water out upon an elevation sufficiently high to cover the

rich slopes and valley lands of the Platte river in the vicinity of Denver. The water is turned into this tunnel by a dam across the river, which cost $20,000. In this dam there is a wasteway built of stones of a uniform size, of four by four feet and eight inches thick, from the celebrated quarries at Fort Collins, in Larimer county, Colorado. The gates in this wasteway are all of iron and of the most approved pattern, and are raised and lowered by screws, so that a boy ten years old could operate them under the heaviest pressure of water. This is probably the longest and most costly canal in the United States for irrigating purposes, and it probably covers a more desirable and more valuable body of lands than any other irrigating canal on the continent; their value being greatly enhanced by their proximity to Denver. The length of the canal, including one branch of ten miles, is eighty-three miles. It extends from the Platte river in a northeasterly direction, and is at one point within four miles of the city of Denver. The width of this canal is forty feet, the depth seven feet, and the average fall per mile twenty-one inches. Its capacity is 1,184 cubic feet per second of time, or 8,887 gallons per second, which will irrigate 59,250 acres, upon the basis of one cubic foot of water per second for fifty acres. The works upon this canal, so far, are of the best character, and it is the intention of the company to maintain it as the model irrigating canal of America. The water is drawn out of the canal at the various places where it is needed, through burnt clay pipes of eighteen inches in diameter, placed under the banks and firmly secured on the inside of the canal in a wall of stone and cement running parallel with the banks. It is the ultimate intention of the company to extend this canal to a point on the Box Elder creek about ten miles north of Box Elder station, on the Kansas Pacific railway, so that a part, at least, of the valley of the creek just named may be irrigated. Farming under this canal was begun in 1883, in which year 3,500 acres were cultivated, and yielded large crops of wheat and oats and other cereals. The land at present —1884—under cultivation is about 15,000 acres, and from present indications all of the land that the canal will irrigate will be brought under cultivation within one to two years.

SUMMARY.

	Capacity in Cubic feet per Second.	Will Irrigate Acres.	Acres Now Irrigated.	Miles Completed.
The Larimer and Weld Canal.	720	36,000	25,000	45
The Loveland and Greeley Canal	446	22,300	10,000	31
The Platte Valley Canal	404	20,200	Just partly built.	28
The Platte Canal	1,184	59,250	15,000	83
Totals	2,754	137,750	50,000	187

The data following are furnished by the Colorado Loan and Trust Company, at Denver, illustrating the interest it has taken in the development of agriculture in the State:

THE GRAND RIVER DITCH COMPANY.

This company operates in the western part of the State, in Mesa county. The company was organized in January, 1883. The canal is taken from the Grand river, at a point fourteen miles east of Grand Junction. The general course of the canal is northwest, past Grand Junction and Fruita, emptying into the great salt wash, a distance of thirty miles from its head. A large lateral is taken out of the canal nearly opposite Grand Junction, which covers the land on the Mesa above the valley proper. The canal is thirty-five feet on the bottom, and will irrigate 65,000 acres of land, carrying about 650 cubic feet of water per second. Its cost in March, 1884, was $170,000.

THE UNCOMPAHGRE CANAL COMPANY.

This company was organized May 29, 1883. The canal is taken out of the Uncompahgre river, in Montrose county, at a point about eight miles above Montrose. It runs in a northwesterly direction into Delta county, twenty-five miles. Its total length, as projected, will be thirty-one miles. It has a width of twenty-six feet on the bottom, and will irrigate 75,000 acres of land, its capacity being 735 cubic feet per second. Its cost was $190,000. It was completed June 1, 1884.

THE CITIZENS' DITCH AND LAND COMPANY.

This company was organized in February, 1882, and operates in Rio Grande and Conejos counties, in the San Luis valley. The canal is taken out of the Rio Grande river near the town of Henry, and runs in a southeasterly direction, a distance of nearly forty-five miles. It is forty feet wide on the bottom, and carries about 990 cubic feet of water per second, irrigating about 100,000 acres of land. The first fifteen miles are completed, and the total cost is estimated to be $210,000, including the purchase of 25,000 acres of State land.

THE PAWNEE DITCH AND IMPROVEMENT COMPANY.

This company was organized in April, 1882. The canal of the company is located in Weld county, northeast of Denver. It is taken out of the north side of the South Platte river, near the town of Merino, and runs in a northeasterly direction past the town of Sterling, a distance of twenty-five miles. It is about thirty feet wide on the bottom, and will irrigate as now built 40,000 acres of land, having a capacity of about 400 cubic feet per second. The cost of the canal, including 11,000 acres of land purchased from the State, was $175,000.

THE FORT MORGAN IRRIGATION COMPANY.

This company was organized in July, 1882. The canal is taken from the South Platte river, at a point two miles below Fremont's Orchard, on the south side of the river, in Weld county. It runs in an easterly direction, to a point three miles south of Brush, on the line of the Burlington and Missouri River railroad. The length of the canal is twenty-six and one-half miles, and it is thirty feet wide on the bottom. It will irrigate 24,000 acres, and has a capacity of 360 cubic feet per second. The cost of the canal, including 5,000 acres of State land, was $100,000. It was finished June 1, 1884.

THE NORTH POUDRE LAND, CANAL, AND RESERVOIR COMPANY.

This company was organized in 1880. The canal is taken out of the north fork of the Cache la Poudre river, northwest of Fort Collins, in Larimer county, and runs in a northeasterly direction, emptying into the Box Elder creek about eight miles southeast of Bristol Station, on the Colorado Central railroad. The canal will irrigate 40,000 acres of land, and is twenty feet wide on the bottom. A number of reservoirs have been built, with a large storage capacity, and the water from them is used when needed during the season. The cost of the canal was $250,000, and it was completed early in the spring of 1884.

THE DEL NORTE LAND AND CANAL COMPANY'S CANAL.

This canal is located in Rio Grande and Saguache counties, in the San Luis valley. It starts from the Rio Grande river about one mile northwest of the town of Del Norte, and runs in a northeasterly direction to a point near the town of Saguache, a distance of thirty-six miles. There are five laterals whose combined length is twenty miles. The company was organized and construction commenced in 1881, but only enough work done to hold the location. On December 1, 1883, work was recommenced, and in ninety days the entire canal was finished and water running in it. The cost of the canal was (approximately) $315,000, which includes 50,000 acres of State land. It is sixty-four feet wide at its head, and six and a half feet deep. Its capacity is about 2,490 cubic feet per second, which should irrigate 250,000 acres.

STATE LAND NO. 2 CANAL COMPANY.

The canal of this company commences at a point on the Rio Grande river about fourteen miles from Alamosa, in Rio Grande county. The company was incorporated in April, 1882, work being commenced at once. The first five miles were completed the same year, when work on excavation was suspended until the following August (1883), when work was resumed and pushed with vigor until completion, June 15, 1884. The canal is twenty-nine miles long and sixty feet wide on bottom, and will irrigate about 50,000 acres, its capacity being very nearly 1,500 cubic feet per second. Its cost, including 74,000 acres of State land, was $345,000. A large lateral, nearly parallel to Denver and Rio Grande railway, and extending eastward for fifteen miles, is to be constructed during the present year. The course of the main canal is southeasterly, and it finally empties into the Conejos river east of La Jara.

VERTEBRATE COLUMNS OF DIFFERENT PEOPLES.

BEFORE the Physiological Society, Berlin, Dr. H. Virchow demonstrated four drawings representing the incurvations of the vertebrate columns of different human types, and manifesting the surprisingly great differences obtaining among the normal vertebrate columns of a Russian, an Italian, a male German existing in model, and a pregnant German wife. From these figures it was to be concluded that the breadth of the normal fluctuations of these incurvations was great. On the study of the vertebral column it was to be observed that it was indeed comparable to an elastic rod which became expanded by lateral pressure and compressed by pressure from the top, but that it was composed of several parts independent of one another (the lumbar, pectoral, and cervical parts), which were adapted to the special functions of the respective sections of the rump. By a simple model he made these differences among the different sections apparent. On a second model he showed that very marked displacements in the center of gravity at the uppermost part of the body were equalized, not by compensatory incurvations, but by bendings in the undermost joints. The speaker then demonstrated by curves rendered in paste the incurvations shown by the vertebral column of dead bodies when the ligaments of the vertebrate bodies in front or behind, in the dorsal or lumbar vertebræ, were cut through. The curves became more marked after the elastic ligaments of the upper vertebræ were cut through, but they hardly changed at all when the lowest tendinous ligaments were cut through. The intestinular ligaments consisted of a soft elastic kernel and of distended ligamentous fibers compressing the kernel. The action of the expanding kernels, which made the vertebral column firmer, was illustrated by a third model. The speaker had taken exact measure of the situation of the kernel in each disk on vertebrate columns sawn through, and when he combined these points on a drawing, he obtained a more marked incurvation than that possessed by the vertebral column. Thus, altogether apart from the muscular activity, the different forces acted on the incurvation of the vertebrate column, which for the rest appeared to be different in the different races.

LEASING OF AN UNSANITARY HOUSE.

A VERY interesting case recently came up in an English court. An owner let to a tenant a house in an unsanitary condition. Shortly after the tenant had taken the house, several members of his family were seized with an illness through, as it was alleged, the escape of sewer gas, and the illness proved fatal to his wife. He claimed damages for the expenses he had incurred in medical attendance and removal, and also for the loss of his wife, at whose death an income of £800 per annum ceased, and the trial ended in favor of the plaintiff, with a verdict for £2,340.

An appeal was had and the verdict set aside, and the case goes to the Court of Appeals. What the final decision will be we can scarcely venture to predict. The *Sanitary World*, a high English authority, in discussing the case, says: "A person about to take a house is not in a position to know much, if anything, as to the state of the drains. On the other hand, the landlord does, or should, and we take it that it is his duty to see that they are properly trapped and in good order, and should certainly ascertain this before letting his house, and if he fails in this respect we certainly think he ought to be held responsible for any ill-effects his tenants may suffer through his negligence."

If, however, the Court of Appeals decides for the defendant, then, the same writer continues, it will "behoove every one who is about taking a house to have it properly surveyed before committing himself by signing an agreement even for a yearly tenancy, or to have a clause inserted in the deed that the drainage of the premises is in perfect order, which possibly would be the better way, as defects in drains are not found out at once. It is possible that the landlord will object to putting a clause of this kind in. We know that it is an unusual one, but that is no reason why it should not be made a usual one, which it would be as well to adopt at once, for even if the plaintiff does appeal, we should have to wait a very long time for the decision, and in the mean time houses will have to be taken; therefore, to make sure, and save after expense, we should advise our readers to follow the course we suggest. If the drainage is all right, surely no owner would object to say so, and have it put in black and white; if he objects to this very reasonable request, his house would be better to remain empty."

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